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WAR NUMBER

Vol. 27 APRIL, 1944 No. 4

Medical Library

AMERICAN HEART JOURNAL

For the Study of the CIRCULATION

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Contents on Inside Cover

American Heart Journal

For the Study of the Circulation

CONTENTS FOR APRIL, 1944

War Number

Editorial ---- 433

Re-examination of 4,994 Men Rejected for General Military Service Because of the Diagnosis of Cardiovascular Defects. G. K. Fenn, M.D., Chicago, Ill., William J. Kerr, M.D., San Francisco, Calif., Robert L. Levy, M.D., New York, N. Y., William D. Stroud, M.D., Philadelphia, Pa., and Paul D. White, M.D., Boston, Mass. ---- 435

Introduction. Robert L. Levy, M.D., William D. Stroud, M.D., and Paul D. White, M.D. ---- 435

Report of the Boston Board. Paul D. White, M.D. ---- 442

Report of the Chicago Board. G. K. Fenn, M.D. ---- 457

Report of the New York Board. Robert L. Levy, M.D. ---- 468

Report of the Philadelphia Board. William D. Stroud, M.D. ---- 484

Report of the San Francisco Board. William J. Kerr, M.D. ---- 493

A Detailed Analysis of the Electrocardiograms of 500 R.C.A.F. Aircrew. Squadron Leader C. B. Stewart and Flight Lieutenant G. W. Manning ---- 502

Analysis of the Electrocardiograms Obtained From 1,000 Young Healthy Aviators. Comdr. Ashton Graybiel, M.C.-V(S), U.S.N.R., Ross A. McFarland, Ph.D., Lt. Comdr. Donald C. Gates, M.C., U.S.N.R., and Lt. Fred A. Webster, H-V(S), U.S.N.R. ---- 524

Some Observations on the Cardiovascular Examination for Aircrew Fitness. Donal P. Murnaghan, M.D., Flight Lieutenant, R.C.A.F. 550

Cardiovascular Experiences in an Army General Hospital. Major Reno R. Porter, M.C., Army of the United States ---- 559

Cardiac Problems in a Station Hospital. Lt. Col. Morton G. Brown, M.C., Fort Devens, Mass. ---- 565

Heart Diseases and Disorders as Causes for Evacuation From the South Pacific Combat Area. Captain Howard B. Sprague, M.C., U.S.N.R., and Lt. Comdr. Sylvester McGinn, M.C., U.S.N.R. ---- 568

Some Practical Aspects of the Rheumatic Fever Problem Which Have an Important Bearing in Military Medicine. Benedict F. Massell, M.D., and T. Duckett Jones, M.D., Boston, Mass. ---- 575

Foreign Bodies in and About the Heart. Major Edward F. Bland, M.C. 588

The Cardiovascular System in Traumatic Shock. Seymour S. Kety, M.D., and Alfred Pope, M.D. ---- 601

American Heart Association, Inc. ---- 610

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American Heart Journal

VOL. 27 APRIL, 1944 NO. 4

War Number

EDITORIAL

THE present number of the AMERICAN HEART JOURNAL consists of various papers of cardiovascular interest which have a direct bearing on the war. They include articles on the problems of cardiovascular examination for admission to the Armed Services and also on cardiovascular problems that face medical officers after the men have been inducted and are in training or on combat duty.

The cardiovascular criteria for admission to the Army (Mobilization Regulations 1-9, adopted also for the enlisted personnel of the Navy) are presented at the end of the introduction of the re-examination paper. A discussion of the individual criteria such as blood pressure, pulse rate, heart size, auscultatory findings, electrocardiography, neurocirculatory asthenia, and history of rheumatic fever appears in the re-examination paper and in several of the other articles.

The most important cardiovascular problem in the Army and Navy is that of the rheumatic heart, especially in its acute phase during rheumatic fever. Indications are at hand to show that a personal or family history of past rheumatic fever is of the greatest importance in identifying those individuals most likely to develop rheumatic fever after exposure to the hemolytic streptococcus. The problem of rheumatic fever is widespread but, naturally, more common in certain regions, as has long been known. A discussion of the subject will be found in the article by Dr. Massell and Dr. Jones.

Neurocirculatory asthenia, which, labeled as such, was a great problem in the last war, is under renewed investigation in the present war. It has not been found, or at least diagnosed, in our Armed Forces in this war, either at home or abroad, nearly as often as in the last war. There are probably several reasons for this, among them a change in style of diagnosis whereby more of such cases are called psychoneurosis or anxiety neurosis; but it also seems likely that the more careful neuropsychiatric examination of the inductees and study of the men in training have weeded out a good many cases from the Service who, in other wars, would have been taken in. Also, the tempo of our Army's fighting has not, to date (Jan. 1, 1944), been as extreme as in the last war.

Other cardiovascular problems in active military service have been minimal. It has been encouraging to find relatively few men with chronic heart disease admitted to the Army and Navy. Here and there, to be sure, one discovers cases, especially those with minimal aortic and mitral valve lesions where the diastolic murmurs are sometimes heard with difficulty. By and large, more men suspected of having heart disease but without it have been excluded than those accepted with supposedly normal hearts who really have some heart disease. As noted above, the development of rheumatic heart disease in service is a major problem. Other types of heart disease are found relatively infrequently. These include cardiovascular syphilis, and hypertensive, pulmonary, and coronary heart disease. Some of the older enlisted men and officers are prone naturally to develop evidence of coronary heart disease, either electrocardiographic or symptomatic, including full-blown myocardial infarction. Most of them are retired from service. Relatively unimportant disorders of cardiovascular function, in particular the arrhythmias, are found occasionally and are dealt with individually. Premature beats are of little or no importance, but paroxysmal tachycardia, especially when frequent, is a cause for rejection as noted in MR 1-9, as are also auricular fibrillation, auricular flutter, and heart block.

It is very important to observe that overemphasis of slight variations of the normal electrocardiogram and of the normal x-ray picture of the heart and great vessels has been one of the common errors in the war, especially in the hands of medical officers who have not had extensive experience and training. Many times the electrocardiogram and x-ray picture have proved more misleading than helpful. This, of course, should not be.

Traumatic lesions of the heart and great vessels in warfare are common, of course, and very often fatal; sometimes, however, recovery ensues, with interesting findings, as noted in Dr. Bland's paper. This traumatic type of heart disease naturally increases when the tempo of the war speeds up. Here expert surgical attention at the front is of prime importance and, with the development of thoracic surgery in recent years, many lives are now being saved.

Vascular injuries and disorders have little representation in this number of the JOURNAL, except for a helpful paper on shock, but it is planned and hoped to present papers along this line in a future number.

It is hoped that a number of physicians in military or in civilian service may have contributions of special military interest and importance that they would like to submit to the JOURNAL for publication. Enough additional papers of value may thus accumulate to permit the publication of a second War Number.

Paul D. White

RE-EXAMINATION OF 4,994 MEN REJECTED FOR GENERAL MILITARY SERVICE BECAUSE OF THE DIAGNOSIS OF CARDIOVASCULAR DEFECTS*

INDIVIDUAL REPORTS BY THE CHAIRMEN OF SPECIAL MEDICAL ADVISORY BOARDS IN FIVE CITIES IN WHICH THE COMBINED STUDY WAS MADE

G. K. FENN, M.D., CHICAGO, ILL., WILLIAM J. KERR, M.D., SAN FRANCISCO, CALIF., ROBERT L. LEVY, M.D., NEW YORK, N. Y., WILLIAM D. STROUD, M.D., PHILADELPHIA, PA., AND PAUL D. WHITE, M.D., BOSTON, MASS.

INTRODUCTION

ROBERT L. LEVY, M.D., WILLIAM D. STROUD, M.D., AND PAUL D. WHITE, M.D.

Members of the Subcommittee on Cardiovascular Diseases, National Research Council

OF THE first two million registrants examined for general military service, one million were rejected for all causes. According to an estimate made by the Selective Service System, approximately 10 per cent of the rejectees were disqualified because of cardiovascular diseases. This rate seemed high for men between 18 and 38 years of age. Accordingly, at a meeting of the Subcommittee on Cardiovascular Diseases of the National Research Council, held in Washington on June 27, 1942, a plan was proposed for the re-examination of a relatively large number of men already rejected for defects of the heart and circulation and for neurocirculatory asthenia. It was hoped that such re-examination would yield information of value for future use concerning particular problems in diagnosis, and that it might result in the salvaging of man power.

The proposal was promptly approved by Major Gen. Lewis B. Hershey, Director of the Selective Service System, and was initiated with the help of Col. Leonard G. Rowntree, Chief of the Medical Division. Upon the recommendation of the Committee on Medical Research, the project was sponsored by the Office of Scientific Research and Development. During the early months of 1943, approximately 5,000 rejectees were re-examined in five large cities by medical boards composed of experts in the field of cardiovascular diseases. Boston, Chicago, New York, Philadelphia, and San Francisco were, for various

*The work described in this paper was done under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and the University of Pennsylvania; and under the auspices of National Headquarters, Selective Service System, Washington, D. C.

reasons, chosen for the study, of which a combined summary report has already been published.*

The individual city reports, which include additional information and suggestions not incorporated in the combined report, are presented herewith, together with the diagnostic nomenclature employed by all of the examining boards. The use of a standard list of diagnoses especially adapted for this work made it possible to prepare uniform tables of results. The standards of physical examination (MR 1-9) used at the time of this study are appended to this introduction.

The reader is referred to the combined report for full discussion; but, for convenience, the summary and conclusions are here republished:

1. An analysis has been made this year of the re-examination, by physicians trained in the study of cardiovascular diseases, of 4,994 men rejected for military service by local boards and induction stations because of the diagnosis of cardiovascular defects or neurocirculatory asthenia. The project was carried out under the auspices of the Selective Service System and with the aid of support from the Office of Scientific Research and Development. The registrants were composed of groups of approximately 1,000 men each, in five cities: Boston, Chicago, New York, Philadelphia, and San Francisco.

2. The chief reasons for the re-examination were to determine (a) the problems in cardiovascular diagnosis that particularly concern the range of the normal cardiovascular system with respect to service, (b) the possible salvage of men for the Army by reclassification as 1A, and (c) the comparison of opinions of cardiovascular experts with those of the examiners at local boards and induction stations to determine the desirability of such re-examinations in this or other special medical fields throughout the country.

3. Of the total number of 4,994 cardiovascular rejectees examined, there were 863 (17.3 per cent) resubmitted as 1A, and 4,131 (82.7 per cent) whose rejection as 4F was confirmed.

4. The percentage of men resubmitted as 1A was quite similar in Boston (18.8 per cent),† New York (19.2 per cent), and Philadelphia (16.5 per cent). In San Francisco 28.6 per cent were resubmitted.‡ Chicago yielded the lowest salvage (3.8 per cent), apparently because of the fact that cardiovascular experts had already been freely used in the decision about doubtful cases, a procedure which might profitably be followed by other examining groups throughout the country.

5. The chief cause for rejection was rheumatic heart disease, found in 2,476 men, or 50 per cent of the total 4,994 and 59.9 per cent of the final 4F group. Mitral valvular disease without aortic valvular disease was diagnosed in the majority of these rheumatic heart cases,

*Levy, R. L., Stroud, W. D., and White, P. D.: Report of Reexamination of 4,994 Men Disqualified for General Military Service Because of the Diagnosis of Cardiovascular Defects, J. A. M. A. 123: 937, 1029, 1943.

†Another 11.4 per cent were considered "borderline" in Boston but after special consideration were not resubmitted.

‡The men resubmitted in San Francisco included a moderate number of "borderline" cases, but in Chicago, New York, and Philadelphia the majority of "borderline" cases were rejected again.

1,500, or 60.6 per cent (750 with obvious stenosis); aortic valvular disease without apparent mitral valve involvement in 280, or 11.3 per cent (72 aortic stenosis and 208 aortic regurgitation alone); and mitral and aortic valvular disease combined in the remaining 628, or 25.4 per cent. Auricular fibrillation complicating mitral stenosis was found in 24 of the cases. The incidence of rheumatic heart disease varied from 70.3 per cent of the rejectees in Chicago to 39.6 per cent in San Francisco.

6. The second most common cause for final rejection was hypertension, found in 1,059 men (25.6 per cent of the 4F group and 21 per cent of the total series). The majority showed elevation of both systolic and diastolic levels; a few had either systolic hypertension alone or diastolic hypertension alone. The incidence varied little from city to city, but it was relatively more common in the fourth than in the third decade.

7. Third in frequency as a cause of rejection was neurocirculatory asthenia with 204 cases (4 per cent of the total series, or 4.9 per cent of those finally labeled 4F). Negroes were rarely affected. The incidence varied from 78 (7.8 per cent) in Boston to 11 (1.1 per cent) in Chicago.

8. The fourth condition responsible for rejection of more than 100 men was sinus tachycardia; there were 189 cases, or 3.8 per cent of the entire group and 4.6 per cent of the final 4F group. The numbers varied from 75 in Chicago to 8 in Philadelphia.

9. The fifth most common cause for rejection was congenital heart disease, found in 183 men (4.4 per cent of the 4F group). The abnormality most commonly diagnosed was ventricular septal defect (Roger's disease) in more than a third of all the cases, 73. Five other defects, in the order of their frequency, were: patency of the ductus arteriosus (29 cases), pulmonary stenosis (13 cases and 2 more with the tetralogy of Fallot), coarctation of the aorta (14 cases), auricular septal defect (6 cases), and subaortic stenosis (5 cases). The city incidence varied from over 6 per cent (63 cases) in San Francisco to 1.8 per cent (18 cases) in Philadelphia.

10. Other causes for rejection included cardiac enlargement alone, determined by x-ray examination (76 cases), arrhythmia in 32, including 17 cases of paroxysmal tachycardia, 6 of uncomplicated auricular fibrillation, 2 of auricular flutter, and 5 of auriculoventricular block, electrocardiographic abnormalities alone in another 32 cases including 10 with bundle branch block, cardiovascular syphilis in only 17 cases, thyrotoxicosis in 14, recent rheumatic fever in 13, cardiac strain from chest deformities in 10, coronary heart disease in only 6, pericarditis in 4, and peripheral vascular defects in 3. Unspecified heart disease was diagnosed in 113 cases.

11. A history of rheumatic fever was obtained in slightly over a fourth of all the cases of rheumatic heart disease (28.8 per cent in

four of the cities) and in nearly half of those in Boston and New York. A history of chorea was rare (1.8 per cent of the rheumatic heart cases in these same four cities).

12. Although the great majority re-examined were white men, there were a good many Negroes (something under 10 per cent, 386 out of 4,035 examined in four of the five cities) and a few Chinese and Filipinos. There was a high rejection rate for Negroes (88 per cent) and a very high rejection rate for the Chinese and Filipinos (100 per cent) in the four cities in which racial data were obtainable. Nine of the fifteen cases of aortic syphilis found in those cities were among Negroes, and hypertension was also more often found in the Negroes (38.5 per cent of the final 4F cases compared to 23.1 per cent for the white men). Rheumatic heart disease was evenly represented (63.8 per cent compared to 63.9 per cent), but neurocirculatory asthenia was very much less common in the Negroes (0.9 per cent compared to 5.5 per cent).

13. There were eight problems of particular interest which remain unsolved and should be the focus of follow-up study but concerning which tentative opinions were expressed: (a) the interpretation of apical systolic murmurs (may they, if very slight or even slight, in the absence of any other abnormal or doubtful finding, be considered inadequate reason for rejection?); (b) the upper limits of the normal blood pressure (may the systolic pressure in very nervous young men be set perhaps as high as 160 mm. Hg or even a shade more, provided the diastolic pressure does not exceed 90 mm. Hg?); (c) the limits of the normal pulse rate at rest (may there not be a wider range, say from 40 to 120 per minute, than that actually given in the current criteria?); (d) the heart size, which also varies widely, especially according to body build, and may perhaps in a few normal individuals exceed the standards set by Hodges and Eyster; (e) the electrocardiogram, of which the wide range of normal has not yet been explored adequately; (f) neurocirculatory asthenia, difficult to diagnose in mild degree, but probably rejectable even when slight, unless there is an obvious cause which can be corrected; (g) recent rheumatic fever, a hazard even when the heart seems perfectly normal; and (h) exercise tests, the usefulness of which, in cardiovascular examination for military service, is open to question.

14. A follow-up study of the men reclassified as 1A and especially of the doubtful "borderline" cases in the final 4F group should, in the years to come, aid in solving some of the various problems in cardiovascular diagnosis that still remain.

15. The wisdom of extending these re-examinations for the sake of the salvage alone is doubtful in view of the time required, the few expert examiners available, and the relatively small percentage of men reclassified as 1A; but the applications of the lessons learned in the course of this study should be helpful in future examinations.

Diagnostic Nomenclature of Cardiovascular Diseases Used by Special Medical Advisory Boards

No cardiovascular disease

Etiologic Type

Bacterial endocarditis—acute
Bacterial endocarditis—subacute
Congenital heart disease (specify lesion if possible)
Coronary heart disease
Hypertension, arterial
Hypotension, orthostatic
Neurocirculatory asthenia
Pulmonary heart disease
Rheumatic heart disease
Syphilitic aortitis

Structural Abnormalities

ENDOCARDIAL

Valvular heart disease—mitral regurgitation—rheumatic
Valvular heart disease—mitral regurgitation—etiology not stated
Valvular heart disease—mitral stenosis, with or without regurgitation
Valvular heart disease—mitral stenosis and auricular fibrillation
Valvular heart disease—aortic regurgitation—rheumatic
Valvular heart disease—aortic regurgitation—syphilitic
Valvular heart disease—aortic regurgitation—etiology not stated
Valvular heart disease—aortic stenosis
Valvular heart disease—combined mitral and aortic disease

MYOCARDIAL

Enlargement of heart (hypertrophy or dilatation, or both)
Enlargement of heart and mitral regurgitation
Myocardial infarction
Myocardial insufficiency (congestive heart failure)

PERICARDIAL

Pericarditis—acute
Pericarditis—chronic

VASCULAR

Aneurysm of aorta
Aneurysm—other than of aorta
Arteriosclerosis
Arteriovenous anastomosis
Lymphedema
Thromboangiitis obliterans
Thrombophlebitis
Other vascular diseases, such as periarteritis nodosa, scleroderma disseminatus, lupus erythematosus disseminatus (specify disease)

Disorders of Function

Adams-Stokes syndrome
Anginal syndrome
Auricular fibrillation
Auricular flutter
Auriculoventricular heart block
Bundle branch block
Carotid sinus syndrome
Paroxysmal tachycardia
Premature beats (extrasystoles)
Raynaud's syndrome (including Raynaud's disease and traumatic vasospastic disease)
Tachycardia (other than paroxysmal)

Mobilization Regulations
No. 1-9

Washington, Oct. 15, 1942
War Department

STANDARDS OF PHYSICAL EXAMINATION DURING MOBILIZATION

Section XIV

Heart, Blood Vessels, and Circulation

62. General service.—a. A heart will be considered normal when the apex impulse is within the left midclavicular line and not below the fifth interspace; when sounds are normal and there are no thrills or important murmurs; when there is no abnormal pulsation or dullness above the base of the heart; when pulse rate is normal and regular and there is no unusual thickening of the arteries or significant elevation of blood pressure.

b. A pulse rate of 100 or over which is not persistent and not due to paroxysmal tachycardia. (A pulse rate of 100 or over may be temporary and due to excitement or to recent infection, such as pneumonia or local infections about the nose, mouth, and throat, or may be induced by drugs.)

c. A pulse rate of 50 or under which is proved to be the natural pulse rate of the individual or to be temporary or due to the use of drugs. (If the bradycardia is physiological, the rate on exercise will rise to a higher level and then gradually return to the original slow rate; whereas, when heart block is present, the rate on exercise will either change slightly or not at all, or sudden interruptions in the length of the heart cycle will be detected.)

d. Sinus arrhythmia. (This consists in a quickening of the pulse rate during inspiration and a slowing during expiration and is best recognized with the individual recumbent and breathing deeply.)

e. Elevation of blood pressure from excitement, proved to be temporary.

f. Neurocirculatory asthenia, if very mild in degree.

63. Limited service.—There are no cardiovascular criteria to warrant initial selection for limited service.

64. Nonacceptable.—a. Circulatory failure evidenced by definite symptoms such as undue breathlessness, pain, or evidence of congestive failure (engorged neck veins, enlarged liver, edema, as well as dyspnea).

b. Hypertrophy and/or dilatation of the heart evidenced by displacement of the apex impulse to the left of the midclavicular line or below the sixth rib, and of a heaving or diffuse character, or by x-ray evidence.

c. A persistent heart rate of 100 or over when this is proved to be persistent in the recumbent posture and on observation and re-examination over a sufficient period of time. See also Section XXI.

d. Paroxysmal tachycardia. See also Section XXI.

e. Heart block.

f. Any serious disturbance of rhythm such as auricular fibrillation.

g. Valvular disease.

h. Congenital heart disease.

i. Persistent blood pressure at rest above 150 mm. systolic or above 90 diastolic, unless in the opinion of the medical examiner the increased blood pressure is due to psychic reaction and not secondary to renal or other systemic disease.

j. Thrombophlebitis of one or more extremities if there is a persistence of the thrombus or any evidence of circulatory obstruction in the involved vein or veins.

k. Other abnormalities of the peripheral vascular system, including large varicose veins, Raynaud's disease, Buerger's disease (thromboangiitis obliterans), erythromelalgia and arteriosclerosis. In doubtful cases special tests should be employed.

l. Aneurysm of any vessel.

m. Pericarditis.

n. Acute endocarditis.

o. True angina pectoris.

p. Coronary thrombosis.

q. Neurocirculatory asthenia (effort syndrome), unless very mild. Usual symptoms of this condition are exhaustion, breathlessness, heartache, and palpitation. These symptoms may follow exertion such as would not produce them in healthy individuals. These and other symptoms, such as dizziness or fainting, may arise without evidence of organic disease sufficient to account for the disability of the individual. Cases of effort syndrome may be divided into four groups. (In some cases more than one of these factors is present.)

(1) As an accompaniment of organic heart disease.

(2) Following infections.

(3) In individuals with poor physique or insufficient training for the work required.

(4) Orthostatic hypotension or tachycardia.—The blood pressure and pulse rate will be taken with the individual in the recumbent position and after standing three minutes. An increase in a normal recumbent pulse rate of 120 beats per minute or more when the individual stands, or a decrease of a normal blood pressure (when the individual is recumbent) to values less than 90 systolic and 60 diastolic when the individual stands may be considered evidence of a definite physiologic disturbance and in itself cause for rejection unless the condition is very temporary following an illness, operation, or exhausted state.

65. Electrocardiogram.—The electrocardiogram is of great assistance in determining the nature of certain cardiac abnormalities, the most important of which are the various arrhythmias, defects in conduction, and diseases of the coronary arteries. The electrocardiograph may be utilized in cases where such diagnostic aid is especially indicated but will not be employed as a routine measure.

66. X-ray.—In doubtful cases, fluoroscopy and teleoroentgenography are advised to determine the size and shape of heart and great vessels. Films taken for the study of the lungs will also be viewed for cardiovascular defects.

REPORT OF THE BOSTON BOARD

PAUL D. WHITE, M.D., CHAIRMAN

THE following pages contain a summary of the re-examination of 1,000 men rejected for military service for cardiovascular reasons or neurocirculatory asthenia by the Boston local boards and Induction Station between the years 1940 and 1943. The re-examinations were carried out by a Medical Advisory Board (No. 16) consisting of the physicians listed below, with the help of secretaries, technicians, and volunteer aides, also listed below. The examinations were conducted at the Massachusetts General Hospital, on Tuesday and Thursday evenings and Saturday afternoons beginning February 4 and ending March 18, each session lasting three to four hours, during which time between 40 and 70 men were thoroughly examined and graded as either 4F, that is, with rejection confirmed, or 1A conservative, that is, with recommendation of acceptance for military service according to the strict interpretation of MR 1-9, or "1A liberal," which group included borderline cases, the criteria for which will be outlined below. All those men recommended as 1A conservative and borderline ("1A liberal") had electrocardiograms taken and were studied roentgenologically. A few other laboratory tests were carried out.

The routine examinations were made, after measuring and weighing the men, in the booths of the Metabolism Laboratory at the Massachusetts General Hospital, by five teams of physicians. For special examination purposes and for resting the men whose blood pressures or pulse rates were too high, small quiet rooms were available in the Cardiac Laboratory. The usual method of examination of the heart was carried out with the individual recumbent and, if necessary, after exercise, using two stethoscopic chest pieces, the Bowles and the bell, and the mercurial sphygmomanometer. The murmurs were graded according to Dr. Levine's classification of: (1) very slight, (2) slight, (3) moderate, (4) loud, (5) very loud, and (6) with murmur heard with chest piece or ear off the chest. Frequent consultations were held between the different teams on special cases and always at least two of the senior examiners agreed on the classification of the men graded 1A conservative and borderline ("1A liberal"). Frequently, all nine examiners were called to conferences during the examining sessions to discuss general principles, special cases, and moot points. One of the examiners, Dr. Cohen, a neuropsychiatrist with cardiovascular training was available for psychiatric consultation.

It was agreed that the men designated as 1A conservative should be sent up some time in the spring by the local boards to the Boston Induction Station for reconsideration, provided they were still liable

for military service. The men designated borderline ("1A liberal") are to be classed temporarily along with those labeled 4F as unsuitable for military service, but because of the importance of this group, a follow-up will be carefully arranged for the future as well as a follow-up of the men in group 1A conservative, whether they have been inducted into the Army or not. Arrangements were made to send the serial numbers of those inducted to Colonel Victor D. Washburn and to the Special Medical Advisory Board, Dr. Paul D. White, Chairman, for the purpose of future follow-up. Copies of the records of all the cases of 4F, 1A conservative, and borderline ("1A liberal"), on the form used, a sample of which is appended, have been retained by Colonel Washburn of the Massachusetts Selective Service and by Dr. Paul D. White.

The examinations went off especially well due to the close cooperation of all those involved, including the examinees, and especially because of the untiring and devoted help of Colonel Victor D. Washburn, Medical officer of the Selective Service in Massachusetts. There was only one untoward event, the sudden death of one of the men previously rejected for rheumatic heart disease, while he was seated waiting for his turn in the examination on Saturday afternoon, March 13. Investigation revealed the fact that this man had been seriously ill with rheumatic heart disease and heart failure a few months before, but had recovered, had recently married, and had been in fair, though probably a mediocre, state of health just prior to his visit to the hospital. He had been ambulatory for weeks and had been doing light work.

MAKEUP OF TEAMS

Team 1.—Dr. Norman H. Boyer and Dr. James Currens.
Team 2.—Dr. Laurence Ellis and Dr. Currens.
Team 3.—Dr. Burton E. Hamilton and Dr. Conger Williams.
Team 4.—Dr. Samuel A. Levine and Dr. Elwyn Evans.
Team 5.—Dr. Paul D. White and Dr. Mandel E. Cohen.

With the constant help of Colonel Victor D. Washburn,
State Medical Officer, Selective Service, Massachusetts.

Secretaries	*Aides*
Miss Helen Donovan	Mrs. Edward F. Bland
Miss Louise Wheeler	Mrs. James H. Currens
Technicians	Miss Edith Terry
Miss Deborah Hanson	Mrs. Robert Vickery
Mr. James Sherlock	Mrs. Paul D. White
Miss Ellen Wood	Mrs. Conger Williams

Special Examinations

Electrocardiograms	375
X-rays	337
Blood tests	2
Urinalysis	9
Metabolism tests	2

CRITERIA FOR 1A CONSERVATIVE AND BORDERLINE

The criteria for classification of the men as 1A conservative and borderline in Boston were briefly as follows:

1. *Murmurs.**—A. Apical.—Individuals with apical murmurs of grade 1 (very slight), with no history of rheumatic fever and no evidence of heart disease, were included in the group 1A conservative. If there was a doubtful or unauthenticated history of rheumatic fever, the classification was borderline unless the very slight murmur was inconstant. If there was a clearcut history, authenticated from hospital or private records, of rheumatic fever in such individuals with apical systolic murmurs, they were classified 4F.

If an apical systolic murmur was of the grade 1+ to 2–, that is, between very slight and slight, the classification was borderline if there was no evidence of heart disease otherwise, and no history of rheumatic fever. If there was a *late* systolic murmur of grade 2, the classification was also borderline.

If an apical systolic murmur was of grade 2 or louder, that is, slight to moderate or loud, rejection was in order unless the murmur was completely dispelled in certain phases of respiration (rare for this loudness of murmur).

B. Aortic Area.—A localized systolic murmur at the aortic area of any intensity, unless extremely slight (grade 1–) and dispelled by respiration, was a cause for rejection.

C. Pulmonary Valve Area.—Systolic murmurs of grades 1 and 2 in the pulmonary area were not a cause for rejection if there was no evidence of heart disease. With full expiration a physiologic murmur might reach close to grade 3 in intensity, but it almost always disappeared on full inspiration. A persistent systolic murmur of grade 3 or more in the pulmonary valve area was considered cause for rejection.

D. Left Sternal Border.—A localized systolic murmur more than slight (grade 2+) at the left sternal border unless dispelled by full inspiration was considered cause for rejection.

E. Diastolic Murmurs.—Any diastolic murmur was a cause for rejection. There were, however, a few cases of slight scratchy to-and-fro murmurs, evidently extracardiac and varying with respiration, which we considered physiologic.

2. *Heart Rate.*—A. A pulse rate of 100 or under, before or after resting, was essential for inclusion in group 1A conservative.

B. Heart rates up to and including 120, if thought to be the result of nervous excitement, in the absence of any evidence of heart disease or infection or thyrotoxicosis, were classified as borderline.

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*Suspicion of cardiac thrills without important heart murmurs should be disregarded. (See Dr. Levine's letter on page 453.)

3. *Blood Pressure* (Average of all readings, systolic and diastolic after 30 minutes rest, were taken as final).—A. Maximum systolic and diastolic pressures of 150 mm. and 90 mm. respectively were required for admission to group 1A conservative.

B. Maximum blood pressures of 170 systolic (if the diastolic pressure was not over 90) and 95 diastolic were permissible for inclusion in the borderline group.

4. *Neurocirculatory Asthenia.*—A diagnosis of neurocirculatory asthenia even of slight or very slight degree was a cause for rejection. The diagnosis was dependent on symptomatology and not on instability of pulse rate or blood pressure, which, however, may be corroborative.

5. *Electrocardiogram.*—A. QRS waves measuring over 0.10 second were a cause for rejection. Those which measured 0.10 second or less were acceptable despite prominence of S waves or unusual shape otherwise. They doubtless are within the range of normal.

B. A P-R interval of 0.20 second was acceptable. Although it is possible that a P-R interval of 0.21 or 0.22 second may be within the range of normal, we have not included such cases in 1A, even under liberal classification.

C. Flattening and inversion of the T waves in Leads I and IV were causes for rejection. Flattening or slight notching of the T waves in Lead II, corrected by change in position of the body or the diaphragm, were within the range of normal provided there was no evidence of heart disease otherwise, and so were acceptable.

6. *X-ray.*—Transverse diameter of the heart shadow by 7 foot film not over 1 cm. above the expected normal for the individual's height, weight, and age, according to the Hodges-Eyster formula by slide rule or nomogram, was acceptable for classification in group 1A conservative. Transverse diameters with measurements up to 2 cm. above the expected normal for the individual's height, weight, and age, were on occasion acceptable for classification as borderline provided there was no evidence of heart disease and *provided* the build of the individual was unusual with wide chest and short stature, usually stocky in addition.

Prominence of the left upper border of the heart and of the pulmonary artery, unless excessive, were not bars to acceptance of the individual in classification 1A conservative provided there was no evidence of heart disease otherwise, and especially if the individual had a vertical heart position.

7. *Rheumatic Fever.*—A history of rheumatic fever prior to five years before examination with the absence of any evidence of heart disease did not bar a candidate from military service. Repeated attacks of rheumatism or rheumatic fever within the last five years, and at any date in the presence of evidence of cardiac abnormality, on the other hand, was cause for rejection. Such history was authenticated.

TABLES SHOWING THE RESULTS OF THE BOSTON RE-EXAMINATION

TABLE I

RE-EXAMINATION OF CARDIOVASCULAR REJECTEES IN BOSTON DURING FEBRUARY AND MARCH, AND ON JUNE 8, 1943

	TOTAL	4F	%	BORDER-LINE	%	1A CONSERVA-TIVE	%
Team 1	186	131	70.5	17	9	38	20.5
Team 2	175	127	73	11	6	37	21
Team 3	219	146	67	38	17	35	16
Team 4	191	141	74	23	12	27	14
Team 5	229	153	67	25	11	51	22
Grand Total	1000	698	69.8	114	11.4	188	18.8

1A Conservative and Borderline (''1A Liberal'') = 302 (30.2 per cent)
4F and Borderline (''1A Liberal'') 812 (81.2 per cent)

TABLE II

4F

(Total—698 Cases)

OUR FINAL DIAGNOSIS	TEAM 1	TEAM 2	TEAM 3	TEAM 4	TEAM 5		TOTALS
Rheumatic heart	86	73	80	74	83		396
Mitral							
Stenosis	15	18	15	22	31	101	
Regurgitation alone	14	6	10	12	14	56	
Aortic							
Stenosis	2	6	4	1	5	18	
Regurgitation alone	8	16	19	5	5	53	
Both mitral and aortic	42	24	31	33	28	158	
Without specification	5	3	1	1	0	10	
(With auricular fibrillation)	(0	3	3	1	6	13)	
Arterial hypertension	25	25	34	38	39		161
Systolic alone	0	0	0	4	6	10	
Diastolic alone	7	5	4	5	2	23	
Systolic and diastolic	18	20	30	29	31	128	
Neurocirculatory asthenia	8	13	12	12	16		61
Congenital*	2	11	14	8	8		43
Coronary heart disease	0	0	0	1	0		1
Heart disease unspecified	5	2	0	0	4		11
Recurrent or recurrent rheumatic fever	0	0	1	4	1		6
Paroxysmal tachycardia	2	0	0	1	0		3
Tachycardia	0	1	0	0	1		2
Auricular fibrillation (2) or flutter (1) without other defects	1	0	1	1	0		3
ECG abnormality*	0	1	0	1	1		3
Special*	2	1	4	1	0		8
Totals	131	127	146	141	153		698

*See Table III.

TABLE III

Congenital Heart Disease	TEAM 1	TEAM 2	TEAM 3	TEAM 4	TEAM 5	TOTAL
Interventricular septal defect	2	5	6	3	5	21
Interauricular septal defect	0	1	2	2	0	5
Subaortic stenosis	0	2	0	0	2	4
Coarctation of aorta	0	2	1	0	0	3
Pulmonary stenosis	0	0	2	0	1	3
Patent ductus arteriosus	0	0	1	1	0	2
Tetralogy of Fallot	0	0	1	0	0	1
Low aorto-pulmonary artery communication	0	0	0	1	0	1
Prominent pulmonary artery	0	0	0	1	0	1
Unspecified	0	1	1	0	0	2
	2	11	14	8	8	43
ECG Abnormalities (3 cases)						
Wide QRS waves (0.11 second)					2	
Abnormally long Q-T interval					1	
Special (8 cases)						
Chest deformity					2	
Thyrotoxicosis					1	
Aortic stenosis (? type)					1	
Cardiac enlargement (? cause)					1	
Albuminuria (persistent)					1	
A-V fistula (lung)					1	
Cardiac neurosis					1	

TABLE IV

1A CONSERVATIVE

(Total—188 Cases)

DIAGNOSIS AT TIME OF ORIGINAL REJECTION NOT CONFIRMED BY US	TEAM 1	TEAM 2	TEAM 3	TEAM 4	TEAM 5	TOTALS
Rheumatic heart	20	13	16	11	19	79
Mitral						
Stenosis	1	2	1	1	6	11
Regurgitation alone	17	7	8	7	4	43
Aortic						
Stenosis	2	0	1	0	1	4
Regurgitation alone	0	1	0	0	2	3
Both mitral and aortic	0	0	1	0	0	1
Without specification	0	3	5	3	6	17
Arterial hypertension	9	14	5	8	16	52
Neurocirculatory asthenia	2	4	1	3	7	17
Congenital	0	2	0	1	2	5
Heart disease unspecified	5	3	10	3	6	27
Recent or recurrent rheumatic fever	0	1	2	0	0	3
Heart block	0	0	0	0	1	1
Tachycardia	0	0	1	1	0	2
Extrasystoles	1	0	0	0	0	1
Angina pectoris	1	0	0	0	0	1
Totals	38	37	35	27	51	188

TABLE V

BORDERLINE ("1A LIBERAL")

(Total—114 Cases)

DIAGNOSIS AT TIME OF ORIGINAL REJECTION (NOT CONFIRMED BY US)	TEAM 1	TEAM 2	TEAM 3	TEAM 4	TEAM 5	TOTALS	POSSIBLE OR QUESTIONABLE BUT NOT PROBABLE DIAGNOSES AS FINALLY ASSESSED BY US
Rheumatic heart	7	2	12	5	4	30	19
Mitral							
Stenosis	0	0	2	4	2	8	0
Regurgitation alone	3	0	6	0	1	10	15
Aortic							
Stenosis	0	0	0	0	0	0	0
Regurgitation alone	0	2	0	0	0	2	1
Both mitral and aortic	1	0	0	0	0	1	3
Without specification	3	0	4	1	1	9	0
Arterial hypertension	5	6	14	8	13	46	70
Neurocirculatory asthenia	0	1	5	5	4	15	2
Congenital	1	0	1	0	1	3	2
Heart disease unspecified	4	2	3	3	0	12	1
Enlargement only							10
Tachycardia	0	0	2	2	2	6	27
ECG abnormality only							2
Other (including unstable cardiovascular system)	0	0	1	0	1	2	0
Totals	17	11	38	23	25	114	114+ 19 with combined diagnoses

ADDITIONAL DATA OF INTEREST

There were a number of other interesting relationships noted on analysis of the records, the more important of which are as follows:

a. Among the 23 Negroes examined, 18 were rejected, 4 were classed as borderline, and 1 was passed. Of the 18, 9 were rejected because of hypertension. There was one man of Chinese origin in the total group; he was rejected.

b. There was nothing of particular interest so far as we could make out in the relationship of the place of residence, city or suburbs, of the place of rejection, local board or Induction Station, or of the year of rejection, and the particular conditions found. The majority of the men examined lived in the city and were rejected in 1942 by the Induction Station. It was true, as would be expected, that there was a larger salvage among the cases rejected by the local boards than in those rejected by the Induction Station.

c. Rheumatic heart disease as a confirmed cause for rejection was found much more commonly in the third decade than in the fourth; this was true also, though less strikingly, for neurocirculatory asthenia, but rejection for hypertension was the other way around.

AGE GROUPINGS OF RHEUMATIC, HYPERTENSIVE, AND NCA CASES

	RHEUMATIC HEART DISEASE		HYPERTENSION		NEUROCIRCULATORY ASTHENIA	
	DECADES		DECADES		DECADES	
	3RD	4TH	3RD	4TH	3RD	4TH
Team 1	60	26	4	21	5	3
Team 2	58	15	4	21	11	2
Team 3	59	21	10	24	7	5
Team 4	58	16	14	24	6	6
Team 5	63	20	10	29	15	1
	298	98	42	119	44	17

AGE GROUPINGS OF ALL CASES

	4F		1A CONSERVATIVE		BORDERLINE		TOTAL	
	DECADES		DECADES		DECADES		DECADES	
	3RD	4TH	3RD	4TH	3RD	4TH	3RD	4TH
No.	451	247	124	64	72	42	647	353
							(1,000)	

d. A history of previous rheumatic fever in the 4F cases of rheumatic heart disease was obtained as follows:

Total cases of rheumatic heart disease	396
Definite history of rheumatic fever	185 (47 per cent)
Questionable history of rheumatic fever	10 (2 per cent)

e. One of the most interesting of all the findings was that of the great diversity of the electrocardiograms among the men who otherwise seemed to be absolutely normal. The range of the normal electrocardiogram is certainly wider than had been previously thought.*

It was noted that among the 1A group, S waves were frequently quite prominent in Leads I and II, either in width or depth, without increase in the duration of the QRS waves. Also, there were some interesting variations in the S-T segments and T waves which at first glance rendered one suspicious; everything else, however, was normal.

CHANGES IN DIAGNOSIS BESIDES THOSE TRANSFERRED FROM 4F TO 1A

The most important change in diagnosis, of course, was in all the cases listed on the previous pages as 1A conservative and in many listed as borderline ("1A liberal"). However, there were, in addition, a considerable number of interesting and important changes in diagnosis in the 4F group, men who were confirmed as 4F but not always for the same reasons. Thus, among the 153 4F cases of Team 5, the original diagnosis was considered incorrect in 21, and, less important, it was considered incomplete in 52 others. Examples of incorrect diagnoses were:

1. Heart disease (wrong) for neurocirculatory asthenia (correct) (6 cases).
2. Neurocirculatory asthenia for tachycardia.

*This has been found also among 1,500 normal aviators, reports of which are published in this issue of the AMERICAN HEART JOURNAL.

3. Rheumatic heart disease for congenital heart disease.
4. Rheumatic heart disease for arterial hypertension.
5. Mitral regurgitation for mitral stenosis.
6. Aortic stenosis for aortic regurgitation.
7. Pericarditis with effusion for rheumatic mitral stenosis with auricular fibrillation and very large heart.
8. Patent ductus arteriosus for ventricular septal defect.

In a number of cases with incomplete diagnoses, defects of one valve and not of the other which was also involved were noted; for example, mitral stenosis might be diagnosed and aortic regurgitation omitted, or vice versa, and, frequently, rheumatic heart disease alone was diagnosed. These were not considered especially important. Though incomplete, they were partial diagnoses, quite likely in an effort to save time, and so were adequate for rejection.

Some errors were encountered by the other teams which need not be rehearsed here, although the details can be found in the original records.

SUMMARY

1. A detailed re-examination of 1,009 cardiovascular rejectees for military service was made in Boston during the months of February and March, 1943. Twelve cases with noncardiac causes for rejection were omitted, leaving 997 cases for the statistical analysis; in order to raise the total to exactly 1,000, six more men were re-examined on June 8 and the first three of these added to the original 997. Nine physicians experienced in cardiovascular examination, including one who had also had extensive neuropsychiatric training, participated. These included Drs. Norman Boyer, Mandel Cohen, James Currens, Laurence Ellis, Elwyn Evans, Burton Hamilton, Samuel A. Levine, Paul D. White, and Conger Williams.

2. Of this number of 1,000 examinees, 69.8 per cent were confirmed as 4F (completely unsuited for military service), 18.8 per cent were recommended as 1A conservative (completely suitable for military service), and 11.4 per cent as borderline (''1A liberal'') cases. It is this borderline group, as well as the 1A conservative group, that should be of much interest for future follow-up, although for various reasons we have not recommended that this borderline group be admitted into military service at the present time. Thus, about 19 per cent were considered as salvageable on the basis of their physical condition, with the probability of a total of about 30 per cent (18.8 plus 11.4) falling within the normal range.

3. Among the individuals designated as 4F, the most common confirmed cause for rejection was rheumatic heart disease, making up 39.6 per cent of the total series, or 56.8 per cent of the 4F group. The second most common cause for rejection was arterial hypertension, making up 16.1 per cent of the total, or 24.4 per cent of the 4F group. The third most common cause was neurocirculatory asthenia, comprising 6.1 per cent of the total, or 8.7 per cent of the 4F group. The fourth most

common cause was congenital heart disease, which comprised 4.3 per cent of the total, or 6.2 per cent of the 4F group. The other miscellaneous causes altogether made up only 40 cases, or 5.7 per cent. Miscellaneous cases included recent or recurrent rheumatic fever, paroxysmal tachycardia, uncomplicated auricular fibrillation or flutter, and coronary heart disease (see tables).

4. Of the rheumatic heart cases, mitral valve disease was diagnosed in 315, that is, in the great majority, being associated with aortic valve disease in 158. Mitral stenosis without aortic valve disease was diagnosed in 101 cases, and mitral regurgitation alone in 56 cases. Aortic stenosis without mitral valve disease was diagnosed in 18 cases, and aortic regurgitation alone in 53 cases. Both mitral and aortic valve disease were diagnosed in 158 cases. Rheumatic heart disease without specification was diagnosed in 10 other cases. In 13 of the rheumatic cases, auricular fibrillation complicated the picture, always associated with mitral valve disease.

5. The majority of the cases of arterial hypertension had both systolic and diastolic hypertension, 128 out of 161 cases. Ten had systolic hypertension alone, and 23 had diastolic hypertension alone.

6. Among the 43 cases of congenital heart disease, ventricular septal defect made up almost half, namely, 21; auricular septal defect was diagnosed in 5 cases, subaortic stenosis in 4, coarctation of the aorta in 3, pulmonic stenosis in 3, patent ductus arteriosus in 2, and tetralogy of Fallot in 1. There were 4 other miscellaneous cases.

7. The most common cause for previous rejection in the group of 1A conservative cases was rheumatic heart disease, 79 cases out of 188 (42 per cent); arterial hypertension was second with 52 cases (28 per cent), and neurocirculatory asthenia was third with 17 cases (9 per cent); unspecified heart disease had been diagnosed in 27 cases and congenital heart disease in 5.

Disabling mitral regurgitation on the basis of an apical systolic murmur had been diagnosed wrongly, we thought, in 43 cases. Mitral stenosis had been diagnosed wrongly in 11, aortic stenosis in 4, aortic regurgitation in 3, and both mitral and aortic valve disease in 1. Disabling tachycardia had been diagnosed in 2. Heart block had been reported in one case in which there was obviously simply an intermittent pulse due to the frequent occurrence of premature beats.

8. In the borderline group which we at first labeled "1A liberal," the chief cause for rejection had been arterial hypertension, in 46 cases out of the 114 (40 per cent). The next most common cause for rejection was rheumatic heart disease, in 30 cases (26 per cent). Neurocirculatory asthenia had been diagnosed in 15 (13 per cent), unspecified heart disease in 12, and disabling tachycardia in 6.

9. The most difficult problems were three in number.

A. The determination of the normal blood pressure range.

B. The interpretation of slight systolic murmurs at the apex.

C. The diagnosis of neurocirculatory asthenia.

It was frequently necessary for all of the group to confer about some of these cases and even then the opinions were occasionally divided. It was for that reason that the borderline group was listed for further study. This included (a) cases with blood pressures a little above the limits ordinarily regarded as the upper range of normal, that is, between 150 and 170 systolic, or between 90 and 95 diastolic; (b) cases with systolic murmurs louder than grade 1 but not louder than grade 2 at the apex; (c) cases with heart rates above 100 and up to and including 120 after resting; and (d) cases with heart size by x-ray above the standards set for the normal upper limit (a transverse diameter up to 1 cm. beyond that calculated), namely, with transverse diameter up to 2 cm. above the expected measurement, provided nothing else was wrong and provided the build of the individual (wide chest and short stature) was in keeping.

10. Two interesting by-products of these re-examinations were: our observation of the attitudes of the men themselves, and a notation of their suitability for the particular work they were doing. In the great majority of cases, the morale of the men seemed to be excellent although a good many were obviously disappointed at not being in uniform. They had become, for the most part, reasonably well adjusted to their rejected status.

The work being carried on by the rejectees was extraordinarily varied and in the main very useful, much of it having to do directly with the war effort, as, for example, employment in shipyards. Only a very few of the men were unable to work at all because of their heart condition.

Attention to their medical needs seemed to have been satisfactory, but we gave further advice here and there as needed, particularly telling them to keep in touch with their own doctors if there was any particular reason for close follow-up.

CONCLUSIONS AND SUGGESTIONS

1. It has been evident from this re-examination in Boston that the care with which individuals having or suspected of having, heart disease or neurocirculatory asthenia have been analyzed and rejected by the local boards and Boston Induction Station has, without doubt, kept low the actual admission of cardiacs into the Army, but, quite possibly, it has excluded a certain percentage of normal men. It is to be expected that such a re-examination as has been carried out by the Special Medical Advisory Board would raise the problem of the range of the normal heart, and result in the recommendation for acceptance of a certain number of those who, at the time of the first examination, were considered doubtful or abnormal.

2. It is possible that a slightly more liberal interpretation of the heart rate, blood pressure, and heart murmurs may reduce the number of cases rejectable, on findings which may be within the range of normal as noted in the present report.

3. Further consideration should be given as to whether all, some, few, or none of the additional criteria for more liberal interpretation of the findings as expressed in this report, called borderline or "1A liberal," may reasonably be added to MR 1-9 for admission to the Armed Services. We have been especially impressed by the unimportance of sinus tachycardia per se, also by the frequency of slight and transient, probably unimportant, elevation of blood pressure (in particular systolic), and by the normal occurrence of very slight heart murmurs in excited young men with active circulations. This group, which we have labeled "borderline" or "1A liberal," is an important one for us to follow in the future from the standpoint of adding to our knowledge of the range of the normal heart. We cannot yet speak with certainty about some of these points, especially the blood pressure and murmurs; perhaps we never shall be able to do so, but such may be possible after further experience in the majority of cases. Appended to this report are some letters from various examiners of our special board, expressing individual opinions concerning some of the moot points.

4. The diagnosis of neurocirculatory asthenia must be based primarily on the history of symptoms and on neuropsychiatric analysis. In these civilians the condition is evident or latent, chiefly in neuropsychiatric cases, in contrast to the less important, although temporarily incapacitating, neurocirculatory asthenia that may involve the more rugged soldiers as the result of all kinds of strain from battle, infection, or other cause for fatigue. Therefore, we consider neuropsychiatric analysis of candidates for military service of prime importance for the detection and elimination of individuals who would be prone to neurocirculatory asthenia.

5. It is evident to us in Boston that this study has been of value, not so much for the salvage of men for the Armed Services, as, particularly, for the clarification of the problems that face the medical examiner of the new recruit and for pointing the direction for future research.

We wish to take this opportunity to express to the Selective Service, to the Medical Department of the Army, and to the civilian workers who have carried out this study, our great appreciation and thanks.

PAUL D. WHITE
Chairman of Boston Special Advisory Board

LETTERS FROM EXAMINERS

Dear Paul:

Thrills.—The notation of thrills should be abandoned entirely. When a thrill is marked and readily timed, there is always a murmur. The thrill is then of no aid in diagnosis. When it is faint it often leads the examiner astray.

Systolic Murmurs.—The most important single notation is the intensity of a murmur. All systolic murmurs of grade 3 intensity or louder should disqualify the selectee. All grade 1 murmurs should be disregarded unless there is other evidence of heart disease or unless there is a definite history of rheumatic infection. If there is only a grade 1 systolic murmur and the rheumatic infection took place more than five years before, if everything else is normal and the man appears fit, he may be

acceptable as "1A liberal." Grade 1 or grade 2 pulmonary systolic murmurs can be accepted as 1A conservative. Apical grade 2 systolic murmurs with heart rate 80 or under, are not acceptable. Grade 2 systolic murmurs with heart rates over 100, with no other evidence of heart disease, can be classified as "1A liberal." Heart rates between 80 and 100 with grade 2 systolic murmurs are open to question.

Heart Rate.—A normal sinus rate of 120 or less should be regarded as insignificant. A resting heart rate of over 120 should disqualify the selectee.

Blood Pressure.—Readings of 160 systolic and 95 diastolic or less, on the first examination or after one-half hour rest period, should be acceptable.

S. A. LEVINE

Dear Dr. White:

Although I took no active part in the discussion at our meeting last Tuesday, I did have some thoughts on the matters discussed. I am in entire agreement that simple tachycardia per se should not be a bar to acceptance into the Armed Forces. In the matter of murmurs, I am in agreement with the last memorandum which you sent out, except that I have wondered about the advisability of accepting grade 1 apical systolic murmurs in the absence of a history of rheumatic fever, and rejecting those with a murmur of the same intensity but with a history of rheumatic fever. In view of the frequency with which diastolic murmurs are found in the absence of positive rheumatic history, it would seem wiser to me to classify on the basis of physical signs alone, and that all grade 1 apical systolic murmurs be accepted or all rejected, but I favor the former.

In the matter of the blood pressure, about which there seemed to be considerable difference of opinion, it seems to me that the crux of the situation lies in General Hillman's report. Presumably, the total number of recruits with borderline or slightly elevated blood pressure is small, and if the numbers of such soldiers who have gotten into difficulties have been great enough to come to General Hillman's attention, it would seem that the problem would be an important one if the number of such recruits were to be increased. Furthermore, I have wondered how great the yield in man power would be if the standards were lowered within reasonable limits. Our experience with the 1,009 rejectees would indicate that the Army would gain only a handful of men out of the thousands examined in Metropolitan Boston.

Sincerely,

NORMAN H. BOYER

Dear Paul:

Here are my thoughts in regard to hypertension and tachycardia as involved in Army induction examinations.

Hypertension.—In regard to elevated blood pressure there are two basic questions to be considered: (1) is the Army interested in men who will make effective soldiers now and in the immediate future, i.e., for perhaps five years, only; or is it also trying to weed out men who will ultimately develop arterial hypertension and its complications, i.e., in ten to forty years; (2) are blood pressure measurements to be employed to discover instances of primary or secondary hypertension only, or else as an objective measure of other types of conditions, especially neurocirculatory asthenia?

I do not believe that men who, we think, will make good soldiers at the present time, but who may ultimately develop hypertension should be excluded from the Army, on the ground that they may ultimately become a charge on the Government, because: (a) we know altogether too little about the detection of hypertension in its incipient or prehypertensive stage; (b) we can tell even less about the rapidity with which hypertension will progress and develop complications in the individual case (with the exception of severe benign or malignant types): (c) we do not know what the policy of the country will be in regard to pensions, etc., after this war, and

the social security program may well bring many of these people under government care even if they have not served in the Army.

Therefore, our problem is to select and weed out men who may get into trouble in the next few years. In regard to this there are no data as to how much, if at all, the rigorous physical conditions of Army life and the state of fear and anxiety in combat situations aggravate early hypertension and precipitate vascular disasters. We must assume they do to some extent. I believe we should exclude men who we really think have significant hypertension at the present time, and my blood pressure criteria for such exclusion would be: a persistent pressure above 160 systolic and 90 diastolic after 30 minutes rest, with the exceptions that, in men with unusually thick (especially muscular) arms, an extra 5 mm. in both systolic and diastolic pressures may be allowed; and also, in the absence of all other reasons for rejection, systolic pressures up to 170 may be allowed provided the diastolic is 80 or below.

In regard to the second question: although abnormal blood pressure measurements may be corroborative of conditions other than primary or secondary hypertension, such as neurocirculatory asthenia, hyperthyroidism, aortic regurgitation, etc., by themselves they are insufficient evidence of any of these, and therefore by themselves should never be the occasion for such diagnoses.

Tachycardia.—In the presence of tachycardia of over 100, conditions such as recent acute infections, neurocirculatory asthenia, hyperthyroidism, heart disease, etc., should be particularly sought for by symptoms and signs, and if the heart rate is over 120 after 30 minutes rest, an electrocardigram should be taken. Simple tachycardia, without any other evidence of disqualifying disease, should not be a cause for rejection unless, after 30 minutes rest, it is over 140.

I enjoyed taking part in the examinations very much and learned a good deal from them, mainly because of the opportunity to compare opinions with you and the others. It seems to me that they were very worth while, not so much from the point of view of the rejectees that we re-examined, as from the knowledge and experience which was gained by all of us, which should be of help in establishing standards for the future. I certainly hope that the men we examined will be followed up in the future.

With best regards,

Sincerely,

LARRY ELLIS

Dear Dr. White:

The observations on neurocirculatory asthenia in this study demonstrated that there is far from unanimity in the definition and diagnosis of this condition.

In 35 cases in which the diagnosis had been made, our group did not substantiate this diagnosis, and the men were put in 1A. In 28 cases the diagnosis of neurocirculatory asthenia was substantiated, and the men were kept in 4F. In 14 cases the diagnosis was changed from neurocirculatory asthenia to some other cardiovascular diagnosis, usually hypertension, and the patient was retained in 4F. In 37 cases the patient who had been turned down for some other reason was kept in 4F with the diagnosis of neurocirculatory asthenia. In other words, we were in agreement with the original diagnosis in 28 cases, and we were in disagreement in 86 cases; that is, we were in agreement with the original examiners in 25 per cent of the cases and in disagreement in 75 per cent of the cases.

The basis of disagreement was apparently, in large part, a matter of definition. It was the feeling of our group that the man's medical history, social history, and work history were more important in the diagnosis than signs such as pulse, blood pressure, and sweating. If the patients had suffered in the past from palpitations, breathing difficulties, chest discomfort, nervousness, or faint and dizzy spells, and these had interfered with the patient's work or activity, it was felt that the diagnosis of neurocirculatory asthenia was justified, and that the patient was not good

soldier material for unlimited service. Tachycardia or hypertension in the absence of previous symptoms we did not feel constituted a useful basis for the diagnosis of neurocirculatory asthenia.

It is desirable that a uniform method of diagnosis for this condition be established at induction boards and in service hospitals.

A related problem which I wish to comment on is that of hypertension. It has seemed to me highly impractical to try to decide in a given case whether a man has "nervous hypertension" or "real hypertension." I don't see that there is much practical importance, for military purposes, of deciding this point. In the absence of complicating heart disease or renal disease, I don't think there is any evidence to show that hypertension of any degree is a handicap in military service. It is true that from the insurance company's point of view a man with hypertension is a poor risk. However, from the Army's standpoint, there probably isn't any valid evidence to show that men with hypertension make poorer soldiers than men with normal blood pressure. Of course, the compensation element has to be considered, but since compensation problems are to such a great extent decided by nonmedical criteria, it does not seem useful to consider this problem in making medical recommendations.

Yours sincerely,

MANDEL E. COHEN, M.D.

ADDENDUM

Of the cases that were considered to belong to the 1A status by the Boston Advisory Board, the following disposition had been made up to Jan. 18, 1944. (The 188 returned by us as 1A were the basis for this group of 190 cases. Two borderline cases were inducted by mistake.)

Commissioned in Army	1	
Inducted, Army	73	
Inducted for limited service	1	
Inducted, Navy	22	
Inducted, Marine Corps	3	
Total		100
Reclassified 4F by Local Board:		
Peptic ulcer	1	
New fracture	1	
Epilepsy	1	
Underweight	1	
Total		4
Reclassified by Local Board:		
1-A-H	5	
2-A	2	
2-B	17	
3-A	6	
3-D	1	
Total		31
Rejected at Induction Station:		
Organic heart disease	2	
Congenital heart disease	1	
Arterial hypertension	3	
History of rheumatic fever	3	
Neuropsychiatric reasons	30	
Neurologic lesions	2	
Other medical reasons	14	
Total		55
Grand Total		190

REPORT OF THE CHICAGO BOARD

G. K. Fenn, M.D., Chairman

OBJECT OF STUDY

THIS study was begun at the instance of National Selective Service and the National Research Council to determine the possible salvage of man power by a careful re-examination of men who had been rejected for military service because of cardiovascular disease.

PLAN

The Chicago Board was organized under the Advisory Chairmanship of Dr. James B. Herrick. The examiners were selected from those men who were competent to recognize the various forms of cardiovascular disease. The Social Service Department of St. Luke's Hospital, Chicago, was selected as the site of the examinations. The Board elected to meet three times weekly, Tuesday and Thursday evenings and Saturday afternoon. The members of the Board were arranged in three groups in order to meet this arrangement, which, however, was soon abandoned, the Saturday afternoon period being given up. Thus, the Board was rearranged to meet the two evening periods each week. Lieut. Col. E. Mann Hartlett, Medical Director of Selective Service for Illinois, met with the Board at the organization meeting and assisted in the formulation of plans. Colonel Hartlett was at all times most helpful and cooperative and promptly met every request of the Board, although these were many and often burdensome.

PERSONNEL

Special Advisory Board No. 39

Advisory Chairman, Dr. James B. Herrick

Dr. G. K. Fenn, Chairman

Dr. Joseph A. Capps
Dr. George H. Coleman
Dr. R. A. Dolkart
Dr. Max P. Gethner
Dr. W. S. Gibson
Dr. N. C. Gilbert
Dr. L. E. Hines
Dr. Frank B. Kelly
Dr. J. Roscoe Miller
Dr. Carl O. Rinder
Dr. Sidney Strauss
Dr. Howard Wakefield

Dr. E. L. Jenkinson, and his staff, of the X-ray Department of St. Luke's Hospital, supplied all x-ray work and the interpretation thereof.

Mrs. Olga Marland, of the Electrocardiograph-Metabolism Department of St. Luke's Hospital, was in charge of integrating the work of the Board with the office of Selective Service. It was her untiring effort and attention to detail that permitted schedules to be met.

Mr. Leo M. Lyons and Dr. A. P. Merrill, of the Administrative Department of St. Luke's Hospital, put all of the necessary facilities of the hospital at the disposal of the Board.

Lieut. Col. E. Mann Hartlett, Medical Director of Illinois Selective Service, was responsible for supplying the men for examination. He always did this cheerfully and at the appointed time.

Clerical Assistants

Lydia Hencky
Merrill Sutherland
Margaret Thompson
Bernace Vander Linden
Margaret Voelker
Margaret Weeden
Clare Weiner
Marion Wiekland

Electrocardiograph Technician

Josephine Knoll

PROCEDURE

Men were sent in by Selective Service from 52 of the local boards situated in the city of Chicago. The smallest number from any single board was one, and the greatest number from any single board was forty-seven. The men were examined, for the most part, on Tuesday and Thursday evenings, beginning at 6:30. The men were selected at random by order number from all of the boards, which were widely scattered throughout the city. The only requirement was that they must have been rejected by the local board or induction center because of cardiovascular disease only. The usual number to report for examination at one session was 60 to 70. The smallest number to report at one time was 18 and the largest number was 109.

A special form, labeled Special Examination of Rejectees With Cardiovascular Defects (DSS Form 1003), was distributed to the local boards. These forms were partly filled out by the local board and were sent by mail, together with the local board or induction station record, to the examining station at St. Luke's Hospital. It was arranged that these records would arrive a few days in advance of the time that the men were required to report for examination.

In all, 1,082 men were registered at the examining station. Of this number, 15 were found to have been rejected for causes other than cardiovascular disease; 37 men were found to have disqualifying defects in addition to cardiovascular disease. This left 1,030 men who qualified for examination in this study. On the last evening of the study, 93 men reported for examination but none of these 93 was recommended for transfer from 4F to 1A. Consequently, the last thirty records were set aside to bring the number to 1,000 men. This made no difference in the number of men transferred from 4F to 1A and made but a small fraction of 1 per cent of difference in the calculation of the causes for rejection.

At every session of the Board, the proportionate number of records were distributed among the members. Many of the records contained reduced x-rays and electrocardiograms. Whenever there was doubt concerning any examinee, a conference of examiners was held. X-rays and electrocardiograms were made routinely on all men recommended for transfer from 4F to 1A.

As a general thing, the instructions contained in War Department MR 1-9 were closely adhered to. In all doubtful cases, 2 meter chest films were made so that the Hodges-Eyster formula might be applied, and electrocardiograms were made. In every case the x-ray and the electrocardiogram were reviewed by the examining physician and by the chairman of the Board.

1. Rheumatic heart disease offered no great difficulty except as far as accuracy in diagnosis of the lesion was concerned. A certain number of cases were obviously unfit for military service, but insufficient time was spent with them to be reasonably certain of the accurate diagnosis. These are listed as unclassified.

2. The hypertensives offered the greatest problem. The Board adhered to the instructions in MR 1-9, but it feels that it is here, if any place, that more liberality might have been shown.

3. The Hodges-Eyster formula was applied to govern excessive heart size. The Board feels that this is not the ideal method of judging increase in heart size. Nine men were rejected because of increase in heart size alone. Two men who were found to have increased heart size were recommended for transfer from 4F to 1A.

4. The Board doubts that the true incidence of syphilitic heart disease is represented by 0.5 per cent.

RECOMMENDED FOR TRANSFER FROM 4F TO 1A

Thirty-eight of these examinees were recommended for transfer from 4F to 1A. While the rejections as a rule did not offer much of a problem, the men who were transferred required very careful study indeed. Only twelve of the thirty-eight were found by the examiners to have no abnormal cardiovascular findings.

In the case of the remaining twenty-six, careful study was required to decide whether or not the abnormal findings were significant. Apart from the electrocardiographic phenomena, which will be discussed under the laboratory work, Table I presents the incidence of abnormal physical findings.

CHICAGO. TABLE I

Systolic murmur (not significant)	9
Systolic murmur (not significant) plus slight increase in heart size	1
Transient tachycardia	2
Transient tachycardia plus slight increase in heart size	1
Transient hypertension	2
	15

The remaining eleven had electrocardiographic findings only.

The Board, after considering all of the evidence, sent this group of thirty-eight men back to the induction center for Class 1A. Colonel Hartlett has promised the Board that he will obtain the Army serial numbers of these inductees. It is proposed to pool these numbers with others obtained in a similar fashion so that the progress of these men may be observed. The local board and induction station diagnoses in these thirty-eight men are given with the individual records.

CHICAGO. TABLE II

EXAMINER	NUMBER EXAMINED	4F TO 1A	%	REJECTION DIAGNOSIS (LOCAL BOARD OR INDUCTION STATION)
Capps	50	None	0	
Coleman	124	5	4	(1) Intermittence of heart beat; (2) hypertrophy and tachycardia; (3) valvular heart disease with mitral regurgitation; (4) heart murmur; (5) tachycardia
Dolkart	12	None	0	
Gethner	120	None	0	
Gibson	37	3	8.1	(1) Mitral regurgitation; (2) heart disease; (3) hypertension
Gilbert	42	2	4.7	(1) Heart murmur; (2) valvular heart disease
Hines	88	7	8	(1) Rheumatic heart disease; (2) hypertension and tachycardia; (3) tachycardia; (4) hypertensive heart disease; (5) cardiac disease; (6) hypertension; (7) enlarged heart
Kelly	83	None	0	
Miller	115	10	9	(1) Hypertension; (2) chronic myocarditis; (3) tachycardia; (4) chronic valvular heart disease; (5) tachycardia; (6) mitral stenosis; (7) mitral lesion; (8) chronic valvular heart disease; (9) valvular heart disease; (10) valvular heart disease with mitral insufficiency
Rinder	91	3	3.3	(1) Systolic murmur; (2) heart murmur; (3) heart murmur
Strauss	59	5	6.9	(1) Systolic murmur and tachycardia; (2) tachycardia and valve disease; (3) systolic murmur on exercise; (4) chronic valvular heart disease with mitral insufficiency; (5) chronic valvular heart disease
Wakefield	164	2	1.3	(1) Chronic valvular heart disease; (2) myocardial damage
Fenn	10	1	10	Chronic valvular heart disease

INDIVIDUAL RECORDS

Table II gives the number of men recommended for transfer from 4F to 1A by each examiner. Included in this list is the number of men examined by each examiner and the percentage recommended for transfer by each examiner. The rejection diagnosis by the local board or induction station is also given.

LABORATORY WORK

In all, sixty-eight electrocardiograms and x-rays, three basal metabolic rates, two urinalyses, and one erythrocyte sedimentation rate were

carried out at the direction of the Board. Many other electrocardiograms and x-rays that had been made elsewhere were reviewed by the Board.

The basal metabolic rate determinations were +30 per cent, +23.5 per cent and –11 per cent. All of these men were rejected. One urinalysis was negative. The other showed the presence of albumin and casts. Both of these men were rejected. The erythrocyte sedimentation rate was within normal limits. This man was transferred from 4F to 1A.

Electrocardiograms and 2 meter chest films were studied in the case of all men transferred from 4F to 1A. The Hodges-Eyster formula was applied to all chest films. With two exceptions, the heart size and contour were normal in all of these x-rays. In two cases, previously mentioned, the actual heart size slightly exceeded the calculated size.

In eighteen of the thirty-eight men recommended for transfer from 4F to 1A, the electrocardiograms were quite normal. In the remaining twenty men the electrocardiogram showed some abnormality. The most common aberration was that of right axis deviation. The Board realizes that axis deviation does not indicate cardiac pathology, but it was rather surprising to find such a large number of right axis deviation curves in this group. It occurred three times alone, and seven additional times with some other finding. Thus, it occurred ten times: in one-half of the cases showing electrocardiographic aberrations, and in 27 per cent of the total number transferred from 4F to 1A. In eleven instances the electrocardiographic change was the sole aberration; in nine instances such changes were associated with other findings.

Electrocardiographic Change Alone		
Right axis deviation alone	3	
Right axis deviation plus aberrant QRS	1	
Right axis deviation plus depressed S-T segment	1	
Left axis deviation	2	
Depression or elevation of S-T segments alone	2	
Depressed T waves alone	2	11
Electrocardiographic Change Plus Other Finding		
Right axis deviation plus systolic murmur	2	
Right axis deviation plus transient hypertension	2	
Right axis deviation plus transient tachycardia	1	
Prolonged P-R interval plus systolic murmur	1	
Aberrant QRS plus systolic murmur	1	
Depressed T waves plus systolic murmur	1	
Marked sinus arrhythmia with nodal escape plus systolic murmur	1	9
Total	20	

In the group that was rejected or continued in Class 4F, thirty x-rays and electrocardiograms were made at the request of the Board. In fourteen instances the x-rays were quite normal. In twelve of these cases the electrocardiograms were also normal, but the men were re-

jected because of persistent tachycardia, hypertension, neurocirculatory asthenia, or some other cause. In two of these cases the electrocardiograms were somewhat abnormal, one showing frequent premature ventricular systoles together with a marked sinus arrhythmia and the other a depressed T wave in Lead IVF together with a left axis deviation and a deeply inverted T_3.

In twelve instances the heart size was more than 1 cm. greater than the predicted size. In nine of these cases no other reason was found for rejection. In three cases the electrocardiograms were also abnormal.

In three instances the heart was within normal limits but had a distinct mitral configuration. In all three of these the electrocardiograms were questionable.

In one instance the x-ray seemed to establish a diagnosis of active pulmonary tuberculosis.

Tables III to XVI represent a tabulation of the causes for rejection in 962 cases that were continued in Class 4F.

CHICAGO. TABLE III

PERCENTAGE OF REJECTIONS IN EACH CATEGORY

CATEGORY	TOTAL CASES (%)	REJECTED CASES (%)
Rheumatic disease	64.8	67.25
Hypertension	19.6	20.0
Congenital heart disease	2.8	2.9
Tachycardia	2.4	2.4
Hyperthyroidism	0.8	0.8
Arrhythmia	0.5	0.5
Unclassified	2.8	2.9
Hypertrophy	0.9	0.9
Syphilis	0.5	0.5
Neurocirculatory asthenia	1.1	1.1

CHICAGO. TABLE IV

RHEUMATIC HEART DISEASE

	NO.	PER CENT
Total examinations	1,000	
Rejected for rheumatic heart disease	648	64.8
Total rejections	962	
Percentage of rejectees with rheumatic disease		67.25
Mitral disease	292	45.0
Mitral insufficiency only	144	22.2
Aortic disease	10	1.5
Aortic insufficiency only	37	5.8
Mitral and aortic	125	19.2
Unspecified*	37	5.8
Rheumatic fever†	3	0.5

Eleven of these men were found to have auricular fibrillation in addition to the other signs of rheumatic heart disease.

*Diagnosis of rheumatic heart disease only, lesion unspecified.

†Rejected because of active rheumatic fever or recent rheumatic fever. No demonstrable heart lesion present.

CHICAGO. TABLE V

CAUSE FOR REJECTION BY LOCAL BOARD OR INDUCTION CENTER* OF 648 SELECTEES REJECTED UNDER GENERAL DIAGNOSIS OF RHEUMATIC HEART DISEASE

Chronic valvular heart disease, unspecified	171
Chronic valvular heart disease, with mitral insufficiency	95
Chronic valvular heart disease, with mitral stenosis	77
Chronic valvular heart disease, with aortic insufficiency	38
Chronic valvular heart disease, with mitral and aortic disease	30
Rheumatic valvular disease	38
Organic heart disease	20
Cardiac hypertrophy	19
Mitral insufficiency	15
Chronic valvular disease, with double mitral	15
Mitral murmur	15
Heart trouble	14
Large heart with mitral murmur	12
Hypertrophy with mitral regurgitation	12
Tachycardia	18
Mitral stenosis	8
Systolic murmur	7
Heart lesion	5
Cardiovascular disease	5
Auricular fibrillation	5
Mitral lesion	4
Aortic diastolic murmur	3
Pericarditis	3
Congenital heart disease	3
Leakage of the heart	2
Systolic and diastolic murmur	2
Myocardial damage	2
Chronic valvular disease, with aortic stenosis	2
Mitral heart disease	2
Arterial hypertension with myocardial damage; mitral and double aortic murmurs; tachycardia with valvular incompetence; thyrotoxicosis and myocarditis; cardiac pathology; aortic obstruction; murmur over valvular heart; rheumatic fever; chronic valvular disease with double aortic; cardiac arrhythmia; heart block; bilateral ocular nystagmus (one each)	12
	648

Of this group, four were Filipino, thirty-nine were Negro, and 605 were white.
*DSS Form 1003.

CHICAGO. TABLE VI

HYPERTENSION

(The Board rejected for hypertension or hypertensive heart disease a total of 196 selectees. In all cases the systolic pressure was more than 150 mm. with the exception of three cases in which the systolic was within normal limits but the diastolic pressure was more than 100 mm.)

DIASTOLIC PRESSURE	REJECTIONS
90-110	57
110-130	57
130-150	15
150 plus	3
Systolic only elevated	27
Diastolic only elevated	3
Unspecified	34
	196

CHICAGO. TABLE VII

CAUSE FOR REJECTION BY LOCAL BOARD OR INDUCTION CENTER* OF 196 SELECTEES IN TABLE VI

Hypertension or hypertensive heart disease	121
Tachycardia	17
Chronic valvular heart disease, unspecified	9
Chronic valvular heart disease, mitral insufficiency	8
Hypertrophy	6
Cardiac lesion	6
Heart disease	4
Systolic murmur	4
Rheumatic heart disease	3
Organic valvular disease	2
Hyperthyroidism	2
Mitral heart disease	2
Double mitral lesion; bronchial asthma (cardiac); cardiovascular disease; nephritis; heart condition; intraventricular block; heart shadow; chronic endocarditis; hyperactive unstable; psychomotor tension; aortic heart murmur; mitral stenosis (one each)	12
	196

Of this group, 23 were Negro; the remainder were white.
*DSS Form 1003.

CHICAGO. TABLE VIII

CONGENITAL HEART DISEASE

(The Board rejected 28 selectees under the diagnosis of congenital heart disease)

Patent ductus arteriosus	6
Patent interventricular septum	9
Coaretation of aorta	2
Unspecified	11
	28

One of the cases of patent ductus had also a dextrocardia.

CHICAGO. TABLE IX

DIAGNOSIS GIVEN BY LOCAL BOARD OR INDUCTION CENTER IN CASES IN TABLE VIII

Congenital heart disease	5
Congenital heart disease, patent ductus arteriosus	6
Chronic valvular disease	4
Coaretation of aorta	2
Chronic valvular disease, mitral insufficiency	2
Heart disease	1
Hypertrophy	1
Mitral systolic and pulmonary heart murmur	1
Rheumatic cardiovascular disease, mitral and aortic	1
Systolic mitral murmur	1
Aortic and mitral murmur	1
Valvular heart disease	1
Cardiac lesion	1
Tachycardia	1
	28

Congenital heart disease was found only in the white selectees.

CHICAGO. TABLE X

TACHYCARDIA

(The Board rejected 24 men because of tachycardia. The diagnosis given in these cases by the local board or induction center is shown)

Tachycardia	17
Hypertrophy	2
Nervous twitching	1
Chronic valvular disease, mitral insufficiency	1
Mitral systolic murmur	1
Heart trouble	1
No cause assigned	1
	24

There were white men only in this group.

CHICAGO. TABLE XI

HYPERTHYROIDISM

(The Board rejected eight men because of hyperthyroidism. The diagnosis given by the local board or the induction center is shown)

Hyperthyroidism	4
Tachycardia	3
Valvular heart disease	1
	8

There was one Negro in this group.

CHICAGO. TABLE XII

ARRHYTHMIA

Five men were rejected because of electrocardiographic abnormalities only. These were classified as follows:

Myocardial damage (electrocardiogram)	2
Pulsus bigeminus	1
Sinoauricular block with frequent premature ventricular systoles	1
Bundle branch block with pulsus alternans	1
	5

The local board or induction center diagnosis in these cases was as follows:

Myocardial damage	2
Cardiac disease; nodal rhythm; bundle branch block (one each)	3
	5

There were five additional cases in which serious arrhythmias were found. These cases are listed here but should not be included in the totals as they have been included in the rejections elsewhere

LOCAL BOARD OR INDUCTION CENTER	REJECTED BY SPECIAL BOARD FOR
1. First degree A-V block	1. A-V block. Rheumatic heart disease with mitral insufficiency
2. First degree A-V block	2. Rheumatic heart disease with mitral insufficiency
3. Valvular heart disease	3. Rheumatic mitral disease with bundle branch block
4. Intraventricular block	4. Hypertensive heart disease
5. Bundle branch block	5. Bundle branch block with rheumatic mitral disease

Chicago. Table XIII

Unclassified

(There were 28 instances in which the examiner made no specific diagnosis. These were cases in which the presence of disqualifying heart disease was obvious but in which the record does not permit accurate classification. The diagnosis given by the local board or induction station is shown)

Chronic valvular disease	14
Hypertrophy	3
Organic heart disease	3
Heart disease	2
Dilatation of heart; syphilis; cardiac damage; congenital heart disease; aortic heart disease; systolic murmur (one each)	6
	28

One Negro is included in this group.

Chicago. Table XIV

Hypertrophy

(Nine men were rejected for hypertrophy only. Enlargement was calculated on the basis of the Eyster-Hodges formula as directed. Diagnosis is shown)

Hypertrophy	3
Rheumatic heart disease	2
Aortic systolic murmur; heart finding; valvular heart disease with mitral insufficiency; no cause (one each)	4
	9

Chicago. Table XV

Syphilis

(In five instances the Board made a diagnosis of syphilitic heart disease. The diagnosis of the local board or induction station is shown)

Hypertension	2
Aortitis	1
Chronic valvular disease	1
Angina pectoris	1
	5

There were no Negroes in this group.

Chicago. Table XVI

Neurocirculatory Asthenia

(In eleven instances the Board made a diagnosis of neurocirculatory asthenia. The admitting diagnosis in these cases is shown)

Tachycardia	4
Valvular heart disease	2
Hypertension and tachycardia	1
Hypertrophy	1
Aortic insufficiency	1
Heart murmur	1
Cardiac disease	1
	11

SUMMARY

Number of men examined and credited to study				1,000
Transferred from 4F to 1A			38	
Rejected, white	892	(Only white selectees transferred from 4F to 1A)		
Negro	66			
Filipino	4			
	962		962	
				1,000
Rheumatic disease		648		
white	605			
Negro	39			
Filipino	4			
Hypertension		196		
white	173			
Negro	23			
Congenital		28		
white only				
Tachycardia		24		
white only				
Unclassified		28		
white	27			
Negro	1			
Arrhythmias		5		
white only				
Hyperthyroid		8		
white	7			
Negro	1			
Hypertrophy		9		
white	7			
Negro	2			
Syphilis		5		
white only				
Neurocirculatory asthenia		11		
white only				
		962		

ADDENDUM

As of Jan. 1, 1944, the status of the thirty-eight men transferred from 4F to 1A was as follows:

Accepted by Army	17
Accepted by Navy	2
1A classification	2
2A classification	2
2B classification	3
4H classification	2
Rejected because of heart defect	3
Rejected because of defect other than heart	7
Total	38

REPORT OF THE NEW YORK BOARD

ROBERT L. LEVY, M.D., CHAIRMAN

PLAN OF STUDY

THE registrants were chosen by the office of the Medical Division of Selective Service Headquarters in New York City. Names were selected from the files of each of the 123 local boards scattered through the boroughs of Manhattan and the Bronx. Men from other boroughs were not included, because of the longer time required for transportation and because it was believed that the material represented a fair sample. An attempt was made to select cases in which the sole cause for rejection was cardiovascular disease; only in a few instances were other defects present. In all, 1,014 men were examined. Several cases were discarded because the cause for rejection was not primarily cardiovascular; one man, for example, had pulmonary tuberculosis and had been treated surgically by thoracoplasty. In a few other instances, associated conditions complicated the situation. The 1,000 cases finally chosen for study met the necessary requirements in a satisfactory manner.

Each local board notified the rejectee to report to the Vanderbilt Clinic of the Presbyterian Hospital at a specified time. The records of the local board and those of the Induction Station, when the registrant had been examined there, were sent to the Chairman of the Examining Board in advance. Electrocardiograms and x-rays, when available, accompanied these records.

Sessions were held on Tuesday and Thursday evenings, beginning at 6:30, and on Saturday afternoons, beginning at 1:30. There were fourteen such sessions, from February 9 to March 11, 1943. From 50 to 110 men were examined at various sessions; during the final period only 14 men were examined to serve as replacements for discarded cases.

A special printed record form, provided by Selective Service Headquarters in Washington, was employed. The first portion was filled out by the clerk at the local board and gave the essential facts concerning the registrant, together with the place and cause of rejection. Below this, the examining physician filled out the history and results of the examination. In making the final analysis of the data, a special coded statistical form was employed from which the tables given in this report were compiled. In the course of the work it was not found necessary to make examinations of the blood or urine, and the exercise test was not considered of sufficient value to be used. The classification employed for final diagnosis was one which had been agreed upon for use in all

of the five cities making these examinations and was based upon the nomenclature recommended by the American Heart Association, though somewhat simplified. To each examiner was given a typewritten list of directions for filling out the charts, together with the nomenclature.

It was arranged with Selective Service that the registrants regarded as not having cardiovascular disease, and therefore reclassified from 4F to 1A, were to be resubmitted to the Induction Station in New York City. A recommendation was made by Brig. Gen. C. C. Hillman, of the Surgeon General's Office, to Col. C. M. Walson, Chief of the Medical Branch, Second Service Command, that the men resubmitted be accepted for active military duty. Colonel Walson has agreed to send to the Chairman of the Special Medical Advisory Board the Army serial number of each man accepted, in order that later he may be traced and his health record and performance in the service may be scrutinized. This group of cases, if so followed, should furnish a valuable check on the validity of the revisions in diagnosis.

PARTICIPANTS IN THE STUDY AND ACKNOWLEDGMENTS

Thirteen physicians, four secretaries, six technicians and two aides constituted the personnel. All were generous with their time and services. The membership was as follows:

Senior Examiners.—Drs. Arthur C. DeGraff, Clarence E. de la Chapelle, B. S. Oppenheimer, Harold E. B. Pardee, Howard F. Shattuck, and Robert L. Levy (Chairman).

Assistant Examiners.—Drs. John M. Baldwin, Jr., Adolph R. Berger, Edwina Campbell, John L. Caughey, Jr., William M. Hitzig, Donald D. Parker, and Grant Sanger.

The senior and assistant examiners constituted Special Medical Advisory Board No. 30.

Secretaries.—Mrs. Edward Armatys, Mrs. John M. Baldwin, Jr., Miss Dorothy R. Bramwell, and Miss Margaret Lawlor.

Technicians.—Miss Helene V. Armstrong, Miss Addie Bauer, Miss Elizabeth Howard, Miss Mary Pembleton, Miss Dorothy Rose, and Mr. Maurice Tate.

Aides.—Mrs. Harry Aranow, Jr., and Miss Barbara Levy.

The facilities of the X-ray Department of the Presbyterian Hospital were made available through the kindness of Dr. Ross Golden, the Director. Dr. Lois C. Collins interpreted and measured all of the chest films. The electrocardiograms were taken with two mobile Cambridge machines and were read by Dr. Robert L. Levy.

Miss Dorothy Kurtz, Supervisor of the Record Department of the Presbyterian Hospital, rendered invaluable help in making the statistical analyses.

Mr. John F. Bush, Executive Vice-President of the Presbyterian Hospital, placed at our disposal one wing on the second floor of the Vanderbilt Clinic; and the Director of the Clinic, Dr. Frederick MacCurdy, saw to it that every facility was at hand.

The project had the support of Col. Arthur V. McDermott, Director of Selective Service for New York City. Through the splendid cooperation of Col. Samuel J. Kopetzky, Chief of the Medical Division, the registrants were chosen, the notices were sent out to the local boards, and all necessary records were handled. Without his constant help the work could not have been carried through to a successful conclusion. A copy of his letter of instruction to the chairman of each local board is appended.

PROCEDURE

Each registrant was seen by at least two of the members of the board, one of whom was a senior examiner. Each case regarded as a candidate for resubmission had a four-lead electrocardiogram and a 2 meter x-ray film of the chest at the conclusion of the physical examination, so that a return visit was not necessary. Interesting cases or those in which the diagnosis was in doubt were seen, as a rule, by most of the examiners present. Unusual or borderline electrocardiograms were discussed by at least three of the senior examiners. Final decision on the cases having electrocardiographic and x-ray examinations was made in every instance by the Chairman of the Board, who had before him the clinical record and the laboratory findings. In making the final diagnosis, all of these were taken into account.

The height and weight were recorded only in those who had x-rays of the chest. This was done in order that the predicted transverse diameter of the heart could be calculated according to the Hodges-Eyster formula.

If the heart rate and blood pressure were normal, a second reading was not taken. If they exceeded the upper limits, both rate and blood pressure were taken again after thirty minutes' rest. Each registrant was examined in a small room, of which some twenty were available. He was allowed to lie quietly by himself, so that the second reading represented basal conditions as nearly as these could be obtained under the circumstances.

COMMENTS ON THE CRITERIA EMPLOYED

The criteria observed were, in general, those outlined in "Standards of Physical Examination During Mobilization," issued by the War Department on Oct. 15, 1942, and referred to as MR 1-9. The following notes present the interpretation placed upon some of these instructions by the New York Board:

1. *Rheumatic Fever or Chorea.*—If the rejectee had an authenticated attack of rheumatic fever or chorea within five years of the date of examination, he was not considered suitable for active service. By

"authenticated" is meant an illness of this sort substantiated by a letter from a hospital or a private physician; in certain cases, an adequate description of the illness by the registrant was considered sufficient. Rejection was made regardless of whether abnormal physical signs were found in the heart.

A registrant was rejected if there was a history of rheumatic fever or chorea, and if doubtful signs of disease were found in the heart. A persistent apical systolic murmur, even though not loud and not well transmitted, was regarded as abnormal under such conditions.

Registrants with a history of rheumatic fever or chorea which had occurred more than five years previously, with no abnormal physical signs, and with a normal electrocardiogram and teleroentgenogram, were resubmitted. A history of more than one attack did not influence this decision.

2. *Hypertension.*—A persistent systolic blood pressure of over 150, or a persistent diastolic of over 90, was considered a cause for rejection. If the systolic pressure was elevated to a level not over 170, the diastolic was normal and if, in the opinion of the examiner, such systolic hypertension was due to nervousness, an exception was made provided no other abnormal findings were present. The association of a normal heart rate with an elevation of systolic blood pressure was considered to be an unfavorable sign. A diastolic pressure above 90, even though the registrant was nervous, was cause for rejection.

A good many of those with hypertension had been sent for observation to the hospital at Fort Jay, on Governor's Island, where readings had been taken on several successive days. These records furnished helpful confirmatory evidence.

3. *Tachycardia.*—A heart rate of over 100 was considered abnormal. It was rare that persistent tachycardia was thought to be of nervous origin. When systolic hypertension also was present, the diagnosis not infrequently was neurocirculatory asthenia.

4. *Systolic Murmurs at the Apex.*—If the murmur persisted in both recumbent and erect positions, was of moderate intensity or loud, was transmitted to the axilla, and was not abolished or significantly diminished by forced breathing, it was considered to be evidence of organic mitral disease, regardless of other findings. Obviously, the presence of cardiac enlargement, an accentuated pulmonic second sound, or an abnormal electrocardiogram afforded added evidence of a cardiac disorder. In a few cases, moderate or loud systolic murmurs were heard which were clearly extracardiac, and in a few others a late systolic click was audible. Provided there were no other signs, the case was resubmitted. The to-and-fro scratchy sound sometimes heard along the left sternal border was considered to be cardiorespiratory in origin and was likewise disregarded.

5. *Systolic Murmurs at the Aortic Area.*—If not associated with any other abnormal finding, provided they were localized and not harsh, such murmurs were not regarded as a cause for rejection. The absence of a thrill did not influence the decision; the presence of a thrill strengthened the opinion that the murmur was significant. Diminution of the intensity of the aortic second sound emphasized the importance of such murmurs.

6. *Diastolic Murmurs.*—All were regarded as pathologic, regardless of location.

7. *Arrhythmias.*—The occurrence of extrasystoles was the only form of arrhythmia in which the decision occasionally was doubtful. If these occurred persistently coupled with normal beats and could not be diminished or abolished by exercise, the candidate was rejected. Such an example occurred but once. Occasional extrasystoles, either ventricular or auricular, were not regarded as a cause for rejection. In every instance the ventricular extrasystoles arose from a single focus, when recorded in the electrocardiogram. Cases with an authenticated history of paroxysmal tachycardia or paroxysmal auricular fibrillation were rejected. In several cases electrocardiograms taken during attacks were furnished by responsible observers or hospitals, so that the patient's statement could be confirmed. Permanent auricular fibrillation was seen only in association with organic cardiac disease. It was, of course, a cause for rejection.

8. *Coronary Occlusion.*—If there was a history of coronary occlusion with cardiac infarction, even though all signs, including the electrocardiogram, were normal, the registrant was rejected, provided he could produce electrocardiograms and clinical notes made at the time of his illness by a physician or in a hosptial. One case of this sort was seen.

9. *Electrocardiogram.*—Any significant deviation from the normal, regardless of whether all other findings were negative, was considered a cause for rejection. Significant findings were bundle branch block with QRS of more than 0.10 second; significant T wave negativity; low T waves in the limb leads (less than 1 mm.); significant RS-T deviation (more than 1 mm. above or below the isoelectric line in the limb leads and more than 2 mm. in Lead IVF); large Q waves in Leads I and IVF (more than 3 mm.); and incomplete heart block. A P-R interval over 0.20 second was considered abnormal. The occurrence of deep S waves in Leads I and II, axis deviation or notching of QRS, unaccompanied by widening of the QRS interval, was not regarded as a cause for rejection. In point of fact, these changes were found only in association with organic heart disease.

10. *X-ray* (2 meter film of heart).—If the transverse diameter of the heart exceeded the predicted transverse diameter, calculated according to the Hodges-Eyster formula, by more than 1 cm., the candidate was rejected even if all other findings were negative. Inasmuch as the Hodges-Eyster formula takes into account height and weight, and

hence variations in body build, as well as age, there was no exception made to this rule. Enlargement as an isolated finding was relatively uncommon; not infrequently it was found associated with some electrocardiographic abnormality, with an abnormal contour of the heart or with other physical signs indicative of disease.

Fluoroscopy was not employed.

11. *Neurocirculatory Asthenia.*—Except in advanced cases, the diagnosis of this condition was difficult on the basis of a single examination. The history was considered important. Tachycardia and moderate hypertension were usually, though not invariably, present. Cold, moist palms often furnished a helpful diagnostic sign. Psychiatric examination was not attempted.

12. *Extracardiac Causes for Rejection.*—Extreme funnel breast, with displacement of the heart to the left, deforming kyphoscoliosis, and severe rachitic deformities of the chest were causes for rejection. These often resulted in displacement of the heart and impaired its functional capacity. There was one instance of toxic nodular goiter with tachycardia, and one of aneurysm of the external carotid artery, traumatic in origin.

RESULTS

A detailed statistical analysis is given in the accompanying tables.

1. *Distribution and Recommendation by Age and Race* (Table I).—Of the 1,000 men examined, 805 were between the ages of 22 and 33 years. Only four were more than 37 years of age. One hundred and ninety-two (19.2 per cent) were considered not to have cardiovascular disease and were resubmitted. Of those resubmitted, the greatest number (78.2 per cent) were between 22 and 29 years of age. Of those rejected only 62.7 per cent were between these ages. The difference, though not great, is worthy of note.

NEW YORK. TABLE I

DISTRIBUTION AND RECOMMENDATION BY AGE AND RACE

AGE AND RACE GROUPS	TOTAL CASES EXAMINED	RESUBMITTED		NOT RESUBMITTED	
		NUMBER	PERCENTAGE	NUMBER	PERCENTAGE
TOTAL CASES	1000	192	100.0	808	100.0
18-21	77	13	6.8	64	7.9
22-25	358	90	46.9	268	33.2
26-29	298	60	31.3	238	29.5
30-33	169	15	7.8	154	19.1
34-37	94	13	6.7	81	10.0
38-41	3	1	0.5	2	0.2
42 and over	1			1	0.1
White	905	180	93.7	725	89.7
Negro	90	12	6.3	78	9.7
Chinese	5			5	0.6

	RESUBMITTED (%)	NOT RESUBMITTED (%)
Of total cases	19.2	80.8
Of total white	19.9	80.1
Of total Negro	13.3	86.7
Of total Chinese		100.0

The majority, namely 905 of the total number, were white; 90 were Negroes; and five were Chinese. Of the white men, 19.9 per cent were resubmitted, and of the Negroes, 13.3 per cent. All of the Chinese were rejected.

2. *Place and Cause of Original Rejection* (Table II).—Of the 1,000 cases, 494 had been rejected by the local draft boards and 506 by induction stations. As was anticipated, of those examined by the local draft boards a greater number (23.5 per cent) were resubmitted than was the case in those examined by the induction stations (15.1 per cent). At the induction stations there was a better opportunity for more careful examination, and in many cases, when the diagnosis was in doubt, the men had been sent to the hospital at Fort Jay for several days' observation.

NEW YORK. TABLE II

PLACE AND CAUSE OF REJECTION

PLACES AND DIAGNOSES	TOTAL CASES EXAMINED	RESUBMITTED		NOT RESUBMITTED	
		NUMBER	PERCENTAGE	NUMBER	PERCENTAGE
TOTAL CASES	1000	192	100.0	808	100.0
Local draft board	494	116	60.4	378	46.8
Induction station	506	76	39.6	430	53.2
REJECTION DIAGNOSES					
Heart disease, unspecified	87	20	10.4	67	8.3
Valvular heart disease, rheumatic	635	109	56.8	526	65.1
Congenital heart disease	18	1	0.5	17	2.1
Coronary heart disease	1			1	0.1
Hypertension	192	43	22.4	149	18.4
Tachycardia	96	27	14.1	69	8.5
Neurocirculatory asthenia	9	1	0.5	8	1.0
Cardiac hypertrophy	55	12	6.3	43	5.3
Cardiac arrhythmia	8	1	0.5	7	0.9
Aneurysm of aorta	1			1	0.1
Aneurysm other than aortic	1			1	0.1
Potential heart disease, rheumatic	1			1	0.1
Chest deformity	2			2	0.2

By far the commonest cause for rejection was rheumatic valvular heart disease, next in importance being hypertension. There followed, in the order of frequency, tachycardia, heart disease of unspecified etiology, cardiac hypertrophy, and congenital heart disease. The percentages among those resubmitted and those not resubmitted followed the same order.

3. *History and Clinical Examination* (Table III).—Of the total number of 1,000 cases examined, 679 had no symptoms, and 321 gave a story of either dyspnea on exertion, paroxysmal dyspnea, pulmonary edema, cardiac pain, or edema of the ankles. Of those not resubmitted, 211 (26.2 per cent) stated that they had either a heart murmur, "heart disease," or high blood pressure; of those resubmitted, 59 (30.7 per

NEW YORK. TABLE III

HISTORY AND CLINICAL EXAMINATION

DETAILS OF HISTORY AND EXAMINATION	TOTAL CASES EXAMINED	RESUBMITTED		NOT RESUBMITTED	
		NUMBER	PERCENTAGE	NUMBER	PERCENTAGE
TOTAL CASES	1000	192	100.0	808	100.0
Symptoms not present	679	188	97.9	491	60.8
Symptoms present	321	4	2.1	317	39.2
HISTORY					
Rheumatic fever over 5 years ago	284	36	18.8	248	30.7
within 5 years	46	1	0.5	45	5.6
Chorea over 5 years ago	41	3	1.6	38	4.7
within 5 years	0	0	0	0	0
Paroxysmal tachycardia	14	1	0.5	13	1.6
Paroxysmal auricular fibrillation	1			1	0.1
Murmur	105	33	17.2	72	8.9
Heart disease	115	16	8.3	99	12.3
Hypertension	50	10	5.2	40	5.0
Other	5			5	0.6
CLINICAL EXAMINATION					
Hypertension, transient	57	47	24.5	10	1.2
persistent, of nervous origin	8	8	4.2		
Tachycardia, transient	48	34	17.7	14	1.7
persistent, of nervous origin	6	6	3.1		
Apical systolic murmur, unexplained	99	99	51.6		
Aortic systolic murmur, unexplained	5	5	2.6		
Extracardiac murmur or click	3	3	1.6		
Cyanosis	6			6	0.7
Clubbing of fingers	4			4	0.5

cent) had this history. Symptoms were absent in 97.9 per cent of those resubmitted and in 60.8 per cent of those not resubmitted.

In the group of 545 cases with a final diagnosis of rheumatic valvular disease, 294 (53.9 per cent) gave a history of rheumatic fever or chorea. Rheumatic fever alone had occurred in 257 (47.1 per cent); chorea alone in 24 (4.4 per cent). The relative infrequency of antecedent chorea is striking. A history of both rheumatic fever and chorea was obtained in only 13 cases (2.4 per cent).

Of the total number examined, 284 stated that they had rheumatic fever more than five years ago, and 46 said that they had it within five years. In 41, there was a history of chorea more than five years ago; in no instance was there a history of chorea within five years. Of those resubmitted, 18.8 per cent said that they had rheumatic fever over five years ago, as compared to 30.7 per cent in those not resubmitted; of those resubmitted, 1.6 per cent had chorea more than five years ago, as contrasted with 4.7 per cent in those who were not resubmitted.

A history of paroxysmal tachycardia was obtained in fourteen of the total number and of paroxysmal auricular fibrillation in one. One man with a history of paroxysmal tachycardia was resubmitted because no substantiation of his story could be obtained and his account of the alleged attacks was not characteristic.

Transient hypertension was observed in 57 cases. Forty-seven of these, together with eight in which hypertension, though persistent, was regarded as of nervous origin, were resubmitted. In the ten showing transient hypertension who were rejected, some other disqualifying condition was present. Transient tachycardia was observed in 48 cases and persistent tachycardia, believed to be of nervous origin, in six. Fourteen of those with transient tachycardia were rejected for some other cardiovascular condition.

An apical systolic murmur of unexplained cause was present in 99 cases, an aortic systolic murmur of unexplained cause was observed in five cases, and in three an extracardiac murmur or click was heard; all were resubmitted. Murmurs at the apex or aortic area which, in the opinion of the examiners, were not due to organic cardiac disease were designated as "unexplained" rather than as functional, physiologic, accidental, or hemic, because the mechanism by which they are produced, as well as their significance, is unknown.

Among the cases of congenital heart disease, cyanosis was observed six times and clubbing of the fingers four times.

NEW YORK. TABLE IV

X-RAY AND ELECTROCARDIOGRAPHIC EXAMINATIONS

FINDINGS	TOTAL CASES EXAMINED	RESUBMITTED		NOT RESUBMITTED	
		NUMBER	PERCENTAGE*	NUMBER	PERCENTAGE*
TOTAL CASES	1000	192		808	
X-RAY					
Not done	709			709	
Total cases done	291	192	100.0	99	100.0
enlargement	69			69	69.7
no enlargement	222	192	100.0	30	30.3
abnormal contour of heart	24			24	24.2
dilated aorta	1			1	1.0
question of tuberculosis	1			1	1.0
ELECTROCARDIOGRAM					
Not done	710	1		709	
Total cases done	290	191	100.0	99	100.0
normal	259	191	100.0	68	68.7
abnormal†	31			31	31.3

*In this case, precentage of cases done by each method of examination.
†For types of abnormality see Table V.

4. *X-ray and Electrocardiographic Examinations* (Table IV).—Two meter films of the heart were taken in 291 cases in which the clinical diagnosis was in doubt. Enlargement of the heart was present in 69; also, 24 showed an abnormal cardiac contour. In one instance, dilatation of the aorta was discovered. In another there were changes suggestive of active tuberculous lesions; this man also had signs of cardiac disease.

Electrocardiograms were done in 290 cases. The record was normal in 259 and abnormal in 31.

NEW YORK. TABLE V

ANALYSIS OF ABNORMAL ELECTROCARDIOGRAMS

TYPES OF ABNORMALITY	PHYSICAL SIGNS OF CARDIOVASCULAR DISEASE	
	NONE	DOUBTFUL
TOTAL CASES	5	26
Bundle branch block (QRS over 0.10 sec.)	3	3
Significant T wave negativity	1	4
T waves low (less than 1 mm. in limb leads)		1
Significant RS-T deviation		2
Q waves large (Leads I and IVF)	1	2
Blocked auricular premature beats		1
Heart block—incomplete (long P-R)		3
Axis deviation, left		6
Axis deviation, right		2
Broad, notched P waves		1
Marked notching of QRS		1
ECG only sign of disease	5	
Final diagnoses in cases in which ECG was abnormal		
Valvular heart disease, rheumatic	19	
Myocarditis, rheumatic (inactive)	1	
Enlargement of heart, etiology undetermined	4	
Congenital heart disease	2	

5. *Analysis of Abnormal Electrocardiograms* (Table V).—In five of the 31 cases the abnormality of the electrocardiogram was the only sign of cardiac disease and was considered of sufficient importance to justify rejection. In three of these, incomplete bundle branch block was observed, with QRS over 0.10 second. In one case with no history of cardiac disease and with a systolic murmur at the apex regarded as cardiorespiratory in origin, the electrocardiogram showed a sharply inverted T wave in Lead IVF. The x-ray revealed no cardiac enlargement. This case was rejected and the final diagnosis was given as "cardiac disease, type unspecified." In another case with neither history nor signs of cardiac disease, and with no enlargement in the teleroentgenogram, the electrocardiogram showed large Q waves in Leads I and IVF, together with left axis deviation. The Q wave in the precordial lead measured almost 5 mm. This man was not resubmitted. The occurrence of deep S waves, without other changes, was considered to be within the normal range.

In the remaining 26 cases, the physical signs were doubtful. In 19 the final diagnosis, after correlating the clinical features and the electrocardiogram, was rheumatic valvular heart disease; in one it was inactive rheumatic myocarditis; in four, on the basis of the x-ray, it was enlargement of the heart of undetermined etiology; and in two the abnormal electrocardiogram was regarded as confirmatory evidence of congenital heart disease, which had been suspected.

6. *Final Diagnoses* (Table VI).—No cardiovascular disease was found in 192 cases (19.2 per cent) and this was the group which was resub-

NEW YORK. TABLE VI

FINAL DIAGNOSES

DIAGNOSES	NO. OF CASES		PERCENTAGE OF CASES NOT RESUBMITTED	
TOTAL CASES	1000			
No cardiovascular disease—cases resubmitted	192			
CASES NOT RESUBMITTED	808		100.0	
Hypertension	159		19.7	
Tachycardia	48		5.9	
Rheumatic valvular disease—total	545		67.4	
mitral regurgitation		190		23.5
mitral stenosis		157		19.4
aortic regurgitation		35		4.3
aortic stenosis		3		0.4
combined mitral and aortic		160		19.8
Syphilitic aortitis and aortic regurgitation	4		0.5	
Suspected syphilitic aortic disease	3		0.4	
Congenital heart disease—total	30		3.7	
patent ductus arteriosus		7		0.9
defect of I-V septum		12		1.5
patent ductus and defect of I-V septum		4		0.5
subaortic stenosis		1		0.1
tetralogy of Fallot		1		0.1
dextrocardia		1		0.1
coaretation of aorta		1		0.1
type not specified		3		0.4
Cardiac enlargement—total	474		58.7	
due to disease specified		454		56.2
etiology undetermined		20		2.5
Myocarditis, rheumatic (inactive)	5		0.6	
External carotid aneurysm	1		0.1	
Coronary sclerosis	2		0.2	
Myocardial infaret, healed	1		0.1	
Neurocirculatory asthenia	31		3.8	
Heart disease due to chest deformity	5		0.6	
Hyperthyroidism	1		0.1	
Thrombophlebitis (inactive)	1		0.1	
Auricular fibrillation, permanent	11		1.4	
Auricular fibrillation, paroxysmal	2		0.2	
Paroxysmal tachycardia	5		0.6	
Extrasystoles (coupled rhythm)	1		0.1	
Bundle branch block	5		0.6	
Diagnosis unspecified	1		0.1	
Rejection and final diagnosis agree	639		79.1	
Rejection and final diagnosis disagree—total	280		-	
cases resubmitted		192		-
cases not resubmitted		88		10.9
Rejection diagnosis incomplete, comparison impossible	81		10.0	

mitted. Of the 808 cases not resubmitted, by far the commonest diagnosis was valvular heart disease of rheumatic etiology. This group comprised 545 cases, or 67.4 per cent. Next in the order of frequency was hypertension, with 159 cases (19.7 per cent). Then, in sequence, came tachycardia, neurocirculatory asthenia, congenital heart disease, and cardiac enlargement of undetermined etiology. Cardiac enlargement due to the disease specified in the diagnosis was present in 454 cases, or 56.2 per cent of the total number.

In the rheumatic group, mitral regurgitation alone was found 190 times and combined mitral and aortic disease 160 times. Mitral stenosis was present in 157 cases and aortic regurgitation in 35. Syphilitic aortitis with aortic regurgitation was observed only four times; in three cases syphilitic aortic disease was suspected. All of the seven cases of aortic syphilis, proved or suspected, were found in Negroes.

Of the thirty cases of congenital heart disease, twelve were considered to be due to a defect of the interventricular septum, and seven to patent ductus arteriosus. In four, these two defects were combined. There was one instance each of subaortic stenosis, tetralogy of Fallot, dextrocardia, and coaretation of the aorta. In three cases the type of congenital defect could not be determined with accuracy and was not specified.

It is perhaps of interest to note that the following conditions were encountered: aneurysm of the external carotid artery, once; coronary sclerosis, twice; healed infarct of the myocardium, once; heart disease due to chest deformity, five times. Permanent auricular fibrillation was observed in eleven cases; all had rheumatic valvular disease.

In 639 cases (79.1 per cent), the original rejection diagnosis and the final diagnosis were in agreement; in 10.9 per cent they were in disagreement; and in 10 per cent comparison was impossible because of the incompleteness of the original record furnished by the local board. Some of the original rejection diagnoses and the final diagnoses replacing them are here given:

Original	*Final*
Valvular heart disease, rheumatic	No cardiovascular disease
	Hypertension
	Congenital heart disease
	Neurocirculatory asthenia
Congenital heart disease	Rheumatic valvular disease
Hypertension	No cardiovascular disease
	Neurocirculatory asthenia
	Rheumatic valvular disease
	Cardiac enlargement—etiology unspecified
Tachycardia	No cardiovascular disease
	Rheumatic valvular disease
	Hypertension
	Neurocirculatory asthenia
Neurocirculatory asthenia	Tachycardia
	Cardiac enlargement
Cardiac hypertrophy	No cardiovascular disease
	Rheumatic valvular disease

7. *Basis of Rejection in Cases Not Resubmitted* (Table VII).—Of the 808 cases not resubmitted, 733 were rejected on the basis of the clinical examination alone, and 75 with the aid of the x-ray or electrocardiogram.

NEW YORK. TABLE VII

BASIS OF REJECTION IN CASES NOT RESUBMITTED

	NUMBER OF CASES	PERCENTAGE OF TOTAL CASES
TOTAL CASES REJECTED	808	100.0
Rejected on clinical examination alone	733	90.7
Rejected with aid of x-ray or electrocardiogram	75	9.3
X-ray decisive	49	6.1
Electrocardiogram decisive	14	1.7
X-ray and electrocardiogram both decisive	12	1.5

Of the 75, 49 were rejected because of cardiac enlargement found on x-ray examination; 14 because the electrocardiogram was either the only abnormality or confirmed doubtful clinical signs; and 12 because both the x-ray and the electrocardiogram were abnormal.

SUMMARY AND CONCLUSIONS

1. In New York City, 1,000 registrants for the Draft, who had been rejected for military service because of cardiovascular defects, were re-examined by a Special Medical Advisory Board. These men had been rejected by local boards or induction stations. Of the total number, 192 (19.2 per cent) were considered not to have cardiovascular disease. By arrangement with Selective Service and the Army, it was agreed that these men should be resubmitted to an induction station, and it was recommended that they be placed in Class 1A and accepted for duty. Their records are to be made available after the war, so that a follow-up study may be undertaken.

2. The plan of procedure during these examinations has been outlined and the criteria for rejection have been described.

3. Rheumatic valvular heart disease was by far the commonest cause of disability (67.4 per cent of the total number finally rejected). Next in order came hypertension, persistent tachycardia, neurocirculatory asthenia, and congenital heart disease. Cardiac hypertrophy of undetermined etiology was found with surprising frequency, namely, in twenty cases.

4. The original rejection diagnosis and the final diagnosis made after re-examination were in agreement in 79.1 per cent of 808 cases not resubmitted.

5. The 2 meter film of the chest was of great value in estimating the size of the heart. In 49 cases it was the decisive factor in furnishing the basis for rejection; in another 12 cases it showed cardiac enlargement when the electrocardiogram likewise was abnormal.

6. The electrocardiogram alone furnished a basis for rejection in only five cases. It was found abnormal in another 26 in which the physical signs were doubtful; in 12 of these cardiac enlargement was discovered in the x-ray film.

7. The occurrence of a systolic murmur at the apex furnished the most difficult problem in diagnosis. A history of rheumatic fever, the intensity of the murmur, the extent of its transmission and its modification by posture and respiration were all factors aiding in the decision as to whether the murmur was indicative of organic disease of the mitral valve. However, judgment was difficult and the accuracy of the final decision is open to question. Only by following a large group of these individuals over a period of years can a true appraisal of the importance of such murmurs be made.

8. The critical levels of systolic and diastolic blood pressures likewise have not been established on a firm basis. Speculation on the basis of present evidence is unfruitful. Until further data are available or until the need for man power becomes acute, it would seem wise to adhere to the criteria at present in use, both because of possible future damage to the individual and because of the danger of swelling the pension lists for disability.

9. The range of the normal heart rate is perhaps subject to a more liberal interpretation. Tachycardia is readily induced by slight emotion and, if unaccompanied by hypertension, probably puts less strain on the circulation than does an increase in blood pressure, particularly when the diastolic level is elevated. Consideration should be given to raising the critical level of the heart rate; it is suggested that if this does not exceed 120 per minute the registrant be accepted.

10. It is worth noting that in the series of fourteen examination periods during which this study was made, there was a gradual tendency to be more liberal in the interpretation of doubtful signs; this attitude applied especially to the apical systolic murmur. At the first session only 13.5 per cent of those examined were resubmitted; at the final session 27.2 per cent of those examined were resubmitted. The trend was gradually upward, though not in an unbroken line.

11. The actual number of men salvaged was relatively small; the labor and expense were considerable. For these reasons, it does not seem feasible or necessary at this time to recommend extension of the work. Yet this survey will not have been made without profit. It has demonstrated the possibility of rejecting a smaller number for cardiovascular defects. It is hoped that it has defined more clearly the criteria for rejection by making them more specific and objective. It has indicated the need for further study of the meaning of certain physical signs, particularly the systolic murmur. It has emphasized the desirability of knowing more concerning the range of normal blood pressure and heart rate. By following the group resubmitted, both in this city and in the others in which similar observations have been made, information should be obtained which will prove useful, not only during war, but in times of peace.

Selective Service, New York City Headquarters
1 East 44th Street, New York City

Hon. Thomas E. Dewey, Governor
Brig. Gen. Ames T. Brown
The Adjutant General, State Director
Col. Arthur V. McDermott
New York City Director

Refer to File: SJK:A January 26, 1943.

To: Chairman of Local Board #----------
Subject:—Re-Examination of Rejected Heart Cases.

1. Under a project of the National Research Council there has been set up in the New York City Area, a special Medical Advisory Board of expert Heart Specialists.

2. These experts are directed to examine registrants rejected for heart disease. The Directive from National Headquarters reads as follows:

> "It is desirable to select ambulant cardiovascular rejectees, exclusive of any rejected because of hemorrhoids or varicose veins, but *including* those rejected for neurocirculatory asthenia, paroxysmal tachycardia, and past and present rheumatic fever.
>
> "Cardiovascular cases bedridden and invalided, or those with other concomitant conditions which would cause their rejection *will not be forwarded.*
>
> "It is expected that D.S.S. Form 1003 will be made out in *sextuplicate.* The local board clerk should *fill in Section I* of the original and all copies of this form and present them *with* the registrant. Any papers pertaining to former physical examinations, x-ray films, or electrocardiograms in this registrant's cover sheet which *may be pertinent* to this *cardiovascular* examination will also be made available to the (special) Medical Advisory Board."
>
> s/s C. G. Parker, Jr., Colonel, U. S. Marine Corps
> Deputy Director

3. The above is being passed on to you for your attention and compliance. Herewith are a number of Forms 1003.

4. Appended are the order numbers of registrants in your Board which the files at this Headquarters list as proper to send to this special Medical Advisory Board.

5. The examinations will be held at the Presbyterian Hospital, 622 West 168th Street, New York City. The examinations will be under the immediate charge of Dr. Robert L. Levy, and will be held for those of your Board on ----------, 1943, at ---------- o'clock.

The following order numbers of registrants of your Board have been selected from our record-files as suitable for submission to this special examination. If for any reason you cannot forward any particular one of the registrants whose order number is listed below, you are at liberty to substitute another whose rejection for heart disease is in your IV-F file. If substitutes are submitted, please send me their order numbers.

The order numbers you are to submit are:

Thank you for your cooperation.

For the New York City Director,
Samuel J. Kopetzky, Colonel, M. C., Medical Division

ADDENDUM

FOLLOW-UP OF 192 MEN RESUBMITTED AFTER RE-EXAMINATION BY THE NEW YORK BOARD, AS OF FEBRUARY 11, 1944

Accepted for Service (total)		140
Army	110	
Navy	27	
Marine Corps	3	

Of the 110 accepted by the Army, two were subsequently discharged for physical disability with the diagnosis of "Valvular Heart Diseases, Mitral Stenosis and Insufficiency. Existed Prior to Induction."

Fifteen who were resubmitted were placed in the following "Deferred Classifications":

1-A-H	1
2-A	3
2-B	10
3-A	2
3-D	1

Thirty-seven who were resubmitted were again rejected, 34 by the Induction Station and 3 by the local board physician. The causes for rejection were:

Cardiovascular (total)		2
Hypertension	1	
Tachycardia	1	
Other (total)		35
Neuropsychiatric reasons	14	
Tuberculosis, pulmonary	5	
Hernia	5	
Defective vision	4	
Orthopedic defect	2	
Administrative reasons	2	
Hemorrhoids (ulcerated)	1	
Duodenal ulcer	1	
Undescended testicle	1	

REPORT OF THE PHILADELPHIA BOARD

WILLIAM D. STROUD, M.D., CHAIRMAN

PERSONNEL

Cardiovascular Examiners:
Samuel Bellet
George C. Griffith
Thomas M. McMillan
George Morris Piersol
William D. Stroud, Chairman

Roentgenologist: Paul A. Bishop

Nurse in Charge: Myra Cassel

Secretarial Group:
Ruth Bruder
Helen Clapp
Grace Martin
Dolores Roberts
Caroline Wittman
Esther Greenburg
Catheryn Grundy
Florida Murphy

Electrocardiographic Technicians:
Catharine B. Sutterley
Margaret G. McCusker

Roentgenologic Technicians:
Selena Black
Isabel Gerber

THE examination of men rejected for cardiovascular disease either by the local examining boards or the Induction Center in Philadelphia was carried on in the Out-Patient Department, at the Pennsylvania Hospital, from January 26 to March 23, 1943. The examinations were made on Tuesday and Friday evenings from 6:30 until 9:30 P.M. There were in all a total of eighteen sessions, with an average of about 58 examined per evening.

The doctors who participated in the examination were members of a Medical Advisory Board (Cardiologic) appointed by the Governor of the State of Pennsylvania, at the request of Lt. Col. B. F. Evans, Acting Director of Selective Service in Pennsylvania. This Board consisted of Drs. Samuel Bellet, George C. Griffith, Thomas M. McMillan, George Morris Piersol, and William D. Stroud, Chairman.

The selection of cases, and the successful arrangement whereby the men were sent by the local boards to the hospital for examination, was almost entirely due to the work of Lt. Col. Edgar S. Everhart, Medical

Officer, Selective Service System, Pennsylvania. Colonel Everhart attended the first session in order to see that things ran smoothly.

The rejectees were sent from 33 local boards in the central part of Philadelphia. This meant that there were quite a large number of men with Italian parentage and a total of 207 (20 per cent) Negroes among the 1,035 men examined.

The men were selected by the local boards by order number, with the supervision of a physician on the board. The local board records were sent to the Pennsylvania Hospital previous to the evening on which each man was to be examined. Upon arriving at the Out-Patient Department, the rejectees were weighed and their heights were taken. Each man was then examined while recumbent, by a member of the Board. If the examiner felt the diagnosis on the rejectee's Form DSS 221 was correct, the special form No. 1003, supplied by Selective Service Headquarters in Washington, was not completely filled out, but a complete diagnosis was made. If the examiner felt the rejectee should be reclassified as 1A, Form 1003 was completely filled out, electrocardiogram and 2 meter films were made, and, if the results were within normal limits, a diagnosis of no organic heart disease was made after consultation with either Dr. McMillan or Dr. Stroud.

As a result, 171 cases with the original diagnosis of the local board or induction center were recommended for reclassification as 1A (see Table I at end of paper).

In the case of 864 men, the examiners agreed with the previous diagnosis and recommended rejection for active service (see Table II).

CRITERIA EMPLOYED

The requirements of Mobilization Regulations No. 1 to 9, by the War Department, Washington, Oct. 15, 1942, Sections 60 to 67, were fulfilled.

A pulse rate of 100 or over, after thirty minutes rest on a bed in a quiet room, was considered disqualifying. It was the opinion of the members of the Board, however, that probably this limit should be raised if all other findings are within normal limits. A blood pressure persistently above 150/90 was considered disqualifying also.

Strangely enough, in the 174 men considered clinically worthy of reclassification as 1A, only three definitely abnormal electrocardiograms were found. Two of these had negative T_1, T_2, and T_3, and one had negative T_2 and T_3, all having had the tracings taken in both the sitting and recumbent positions. In spite of the negative clinical findings, these cases were not recommended for reclassification as 1A. A number had left axis deviation, which was considered due to the individual's build, and a number had multiple premature contractions, which were not considered disqualifying. Electrocardiograms were done only on those clinically recommended for reclassification.

Dr. Paul A. Bishop, the Roentgenologist at the Pennsylvania Hospital, devoted a great deal of time to studying the 2 meter films of those considered clinically to have normal hearts. He found 45 of the rejectees with transverse cardiac diameters of 1 cm. or more above the predicted normal for their height, weight, and age, according to the table of Hodges and Eyster. After carefully going over the clinical picture and the films of these cases with members of the Medical Advisory Board, he agreed that, of the 45, only nine had sufficient x-ray evidence of cardiac enlargement to cause rejection.

RESULTS

The two most difficult problems were a systolic murmur at the cardiac apex and increased heart rates with blood pressures slightly above normal. Many men originally classed as 4F had only a systolic murmur in the pulmonic region, which was considered functional. Of the 160 men rejected for mitral insufficiency without cardiac enlargement, a great many, we believe, did not have organic valvular heart disease, but the loudness of the murmur in certain positions and following exercise caused rejection, because of the possibility that, if reclassified, they would be discharged from the Service sooner or later.

It is interesting to note that by far the majority of cases not recommended for reclassification had rheumatic heart disease—569 men, or 66 per cent. Two hundred men, or 23 per cent, had arterial hypertension, and 54 men, or 6.2 per cent, had neurocirculatory asthenia.

Of the 1,035 men examined, 207, or 20 per cent, were Negroes. Of these, 33, or 16 per cent, were recommended for reclassification as 1A. Of the 569 men with rheumatic heart disease, 111, or 19.5 per cent, were Negroes. Of the 200 men with arterial hypertension, 54, or 27 per cent, were Negroes. It is interesting how few cases of neurocirculatory asthenia were observed in Negroes, namely, 2, or 3.8 per cent, out of a total of 54 of such cases.

We were much surprised to find how seldom a positive history of rheumatic fever was obtained in cases with definite rheumatic heart disease. Of 569 such cases, only 89 (15.6 per cent) gave a history of rheumatic fever, and only 4 (0.7 per cent) a history of chorea.

Appended are three letters from members of the Board, outlining their reactions to the study. They are worth reading carefully.

In closing, I cannot help thanking all of those who participated in this study for their cheerful cooperation and hard work. It was a long, and at times a tiresome, job, but I believe that the results have been worth while.

LETTERS FROM EXAMINERS

Dear Dr. Stroud:

Regarding the re-examination of rejectees the following thoughts come to mind:

The causes for rejection of selectees are subdivided under the following headings:

Murmurs.—The great majority rejected because of valvular disease were found to have organic murmurs at the apex or base, or both. The remainder who were considered acceptable for service showed the following findings.

a. No murmurs.

b. Systolic murmurs at the pulmonic region which were considered functional. These had been labeled as organic of the acquired or congenital type.

c. Systolic murmurs at apex—Grade I (definitely functional).

d. Systolic murmurs at the aortic area.

In many, a systolic murmur was produced, or, if previously present, was exaggerated, by tachycardia and/or hypertension.

The large single group in which doubt arose were those with Grade II systolic apical murmurs, who gave no history of rheumatic infection, had no symptoms referable to the cardiovascular system, and showed a heart normal in size and shape upon roentgen study. Many of these, we believe, had no endocardial lesion and could be acceptable for service. They were able, in many instances, to work at an occupation involving strenuous physical effort without symptoms.

Hypertension.—Most of those rejected for hypertension showed hypertension. Those of this group considered acceptable presented:

a. No hypertension on our examination.

b. A rise in blood pressure to 160 or 170 mm. which dropped to normal upon resting in bed for 10 to 20 minutes. The hypertension in these cases was considered to be of psychic origin.

The remainder showed blood pressure readings of 160 mm. and over, which persisted after a thirty-minute rest and were associated, in many instances, with a tachycardia, cardiac enlargement, and a Grade II systolic apical murmur.

The hypertensive group is important, not only because of its size but because it is frequently a transient manifestation of anxiety and may be produced by malingerers. Considerable care and investigation are required before rejection of these cases. I mention the following as illustrative: Last week I examined a young man of 32 years who had been rejected at the Induction Center because of high blood pressure; he had had two readings of 160 and 190 mm.; at my office he had a blood pressure of 140 mm., and showed a heart that was entirely normal.

In this connection it might be stated that the environmental conditions for examining hypertensives at the Induction Board at 32d and Lancaster Avenue are not particularly good. There are no separate rooms and people are constantly milling about. The selectees are usually under severe nervous strain at the time of the examination; many have spent sleepless nights before this event, and others have engaged in various types of dissipation and have imbibed large amounts of coffee and other stimulants. These are all factors in raising the blood pressure and should be discounted in determining the basal status of the individual selectee.

Tachycardia.—Simple tachycardia, with rate over 100 per minute, was frequently encountered. This group may be divided into several categories:

a. Where the patients normally have a high pulse rate (a small group).

b. Where the acceleration is the result of nervousness and worry and may be considered part of an anxiety state.

c. Mild grade of hyperthyroidism.

d. Where the acceleration was the result of additional factors which may border on malingering, due to factors similar to those mentioned under hypertension.

The possible use of benzedrine and other sympathetic stimulating drugs should be ruled out.

Cases in which the pulse rate exceeds 110 per minute under conditions which are considered basal should be rejected.

Comment.—After perusal of the various reports from different parts of the country, it might be desirable to establish new criteria for acceptance of cardiacs,

at least to define more clearly the borderline groups. Based on these, it might be of interest to repeat this study in other parts of the country.

These standards might be also utilized by draft board physicians for future cardiac evaluations.

SAMUEL BELLET

Dear Dr. Stroud:

In re the re-examination of rejectees, the following thoughts come to mind:

1. This Medical Advisory Board's examination of rejected cardiovascular subjects was of value to the rejected selectee, because it answered any doubt which he might have in mind regarding his disability.

2. It was of value to the Selective Service, because it restored to the Selective Service approximately 17 per cent of the men examined, making them available for active military duty.

3. Examinations were of value to the physicians composing the Advisory Board, because they called for the necessity of making a definite decision with the aid of exceedingly well-trained colleagues.

4. Examinations were of great value to the medical profession, and an opportunity for real study should be called to the attention of the American Medical Association, the College of Physicians, the American Heart Association, and local heart associations.

5. The study should prove of real value to the Rehabilitation Committee, who should use this data for war and postwar planning for extended rehabilitation.

GEORGE C. GRIFFITH.

Dear Dr. Stroud:

In re the re-examination of cardiovascular rejectees, the following thoughts come to mind:

I believe that the final tabulation showed that we recommended for re-examination some 20 per cent of the 1000 rejectees examined.

It is my feeling that if these 1000 young men had been examined in our offices as civilians, we probably would have decided that at least 60 per cent had no organic circulatory disease. It was my feeling that a considerable percentage of those rejected had no organic cardiovascular disease. However, there is good reason for this discrepancy, and, in my opinion, we would have made a mistake had we sent back for re-examination many more than we did return.

In this sort of work I think it is necessary to set up certain standards and to adhere to them. For, after all, we were not the last word; we had no authority to do more than recommend a re-examination. We would have erred, therefore, in returning persons who showed certain findings which subsequent examiners would regard as cause for rejection even though we, as specialists, felt that these findings were unimportant. In other words, we should not use our special knowledge and experience too finely, and should not apply it beyond the point which subsequent examiners can readily accept.

Murmurs were, as ever, a source of difficulty. In deciding to reject any one who showed a definite apical systolic murmur, I think we acted properly, though many so rejected did not, in my opinion, have organic heart disease. I think it was also a sound decision to accept murmurs (1) that were heard at the aortic area, but were soft; (2) that were not heard in all phases of respiration; (3) that clearly originated at the pulmonic area; (4) that were late in systole and soft, even if they were best heard at the apex. I believe subsequent examiners will find it possible to accept and follow these criteria.

Many that were rejected for mild hypertension or for a rapid heart rate certainly had no organic circulatory disease. However, after my experiences with

neurocirculatory asthenia in France in the last war, I am of the opinion that those whose blood pressure goes above 160 or whose pulse rate reaches 120, as a result of the excitement incident to an examination, and which do not return to normal after a half hour's rest in the prone position in quiet surroundings, are not good candidates for the Army. I think, incidentally, that a heart rate of 100 is a little too low. I would be inclined to raise it to 110 or even 120 before considering this a cause for automatic rejection.

THOMAS M. MCMILLAN

PHILADELPHIA. TABLE I

REJECTEES RECOMMENDED FOR RECLASSIFICATION AS 1A

DIAGNOSIS OF LOCAL BOARD OR INDUCTION CENTER	TOTAL (NO.)	TOTAL (%)	WHITE (NO.)	WHITE (%)	NEGRO (NO.)	NEGRO (%)
Valvular heart disease	97	56.7	77	79.4	20	20.6
Arterial hypertension	33	19.3	25	75.8	8	24.2
Tachycardia	14	8.2	13	92.9	1	7.1
Cardiac enlargement	5	2.9	5	100.0		
Heart condition	12	7.0	9	75.0	3	25.0
Neurocirculatory asthenia	4	2.3	3	75.0	1	25.0
Cardiac arrhythmia	2	1.2	2	100.0		
Hyperthyroidism	1	0.6	1	100.0		
Presence of rheumatic fever	1	0.6	1	100.0		
Congenital heart disease	1	0.6	1	100.0		
Psychoneurosis	1	0.6	1	100.0		
Total	171	16.5	138	80.7	33	19.3

PHILADELPHIA. TABLE II

REJECTEES NOT RECOMMENDED FOR RECLASSIFICATION

DIAGNOSIS OF MEDICAL ADVISORY BOARD (CARDIOLOGIC)	TOTAL (NO.)	TOTAL (%)	WHITE (NO.)	WHITE (%)	NEGRO (NO.)	NEGRO (%)
Rheumatic heart disease						
Mitral insufficiency	160		134		26	
Mitral insufficiency (C.E.)*	148		100		48	
Mitral stenosis	131		115		16	
Aortic insufficiency	4		1		3	
Aortic insufficiency and mitral insufficiency	37		28		9	
Aortic insufficiency and mitral stenosis	54		49		5	
Aortic stenosis and mitral insufficiency	16		12		4	
Aortic stenosis and mitral stenosis	19		19			
Total rheumatic heart disease	569	65.9	458	80.5	111	19.5
Hypertension—arterial	200	23.1	146	73.0	54	27.0
Neurocirculatory asthenia	54	6.2	52	96.2	2	3.8
Congenital heart disease; pulmonary stenosis	9	1.0	7	77.8	2	22.2
Congenital heart disease; patent ductus arteriosus	4	0.5	4	100.0		
Congenital heart disease; patent ductus arteriosus; pulmonary stenosis	1	0.1	1	100.0		
Congenital heart disease; patent interventricular septal defect	4	0.5	1	25.0	3	75.0
Syphilitic heart disease; aortitis	2	0.2			2	100.0
Syphilitic aortic insufficiency	1	0.1	1	100.0		
Tachycardia	8	0.9	8	100.0		
Rejected on x-ray alone	9	1.0	9	100.0		
Rejected on electrocardiogram alone	3	0.3	3	100.0		
Total	864	83.5	690	79.8	174	20.2

*C.E. = Cardiac enlargement.

PHILADELPHIA. TABLE III

RESULT OF RE-EXAMINATION BY SPECIAL BOARD

Total number examined	1,035
Number resubmitted	171
Number rejected	864

PHILADELPHIA. TABLE IV

ORIGINAL REJECTION DIAGNOSES

(By Local Board or Induction Station)

DIAGNOSES	NUMBER FINALLY RESUBMITTED	NUMBER FINALLY REJECTED
Rheumatic valvular heart disease	97	550
Hypertension	33	227
Tachycardia	14	35
Congenital heart disease	1	10
Cardiac hypertrophy	5	5
Rheumatic fever—recent	1	1
Heart disease—unspecified	12	26
Neurocirculatory asthenia	4	3
Cardiac arrhythmia	2	1
Cardiac neurosis	1	
Syphilis of aorta		3
Aneurysm of aorta		
Aneurysm, other than aortic		
Heart disease due to chest deformity		
Coronary heart disease		
ECG abnormality only		
Peripheral vascular disease		
Pericarditis		
Nephritis (persistent albuminuria)		2
Hyperthyroidism	1	1
Total	171	864

PHILADELPHIA. TABLE V

FINAL REJECTION DIAGNOSES IN CASES NOT RESUBMITTED BY SPECIAL BOARD

Rheumatic valvular heart disease	569
Hypertension	200
Tachycardia	8
Congenital heart disease	18
Syphilis of aorta	3
Aneurysm of aorta	0
Aneurysm other than aortic	0
Cardiac enlargement only	9
Myocarditis, rheumatic	0
Coronary heart disease	0
Heart disease, unspecified	0
Neurocirculatory asthenia	54
Auricular fibrillation—paroxysmal	0
Auricular fibrillation—permanent	9
Paroxysmal tachycardia	0
Cardiac arrhythmia only	0
Cardiac neurosis	0
Recent rheumatic fever	0
Pericarditis	0
Heart disease due to chest deformity	0
ECG abnormality only	3
Peripheral vascular disease	0
Nephritis (persistent albuminuria)	0
Hyperthyroidism	0

PHILADELPHIA. TABLE VI

TYPES OF RHEUMATIC VALVULAR HEART DISEASE IN REJECTED CASES

(Final diagnoses by Special Board)

Total number cases rheumatic valvular disease	569
Mitral regurgitation	308
Mitral stenosis	131
Aortic regurgitation	4
Aortic stenosis	0
Combined mitral and aortic	126

PHILADELPHIA. TABLE VII

HISTORY OF RHEUMATIC FEVER OR CHOREA IN CASES WITH VALVULAR HEART DISEASE

History of rheumatic fever	89
History of chorea	4
History of both rheumatic fever and chorea	0

PHILADELPHIA. TABLE VIII

TYPES OF CONGENITAL HEART DISEASE IN REJECTED CASES

(Final diagnoses by Special Board)

Patent ductus arteriosus	4
Defect of I-V septum	5
Defect of I-A septum	
Subaortic stenosis	
Tetralogy of Fallot	
Coarctation of aorta	
Pulmonic stenosis	9
Dextrocardia	
Low aorto-pulmonary artery communication	
Prominent pulmonary artery	
Combined lesions	
Patent ductus and I-V septal defect	
Patent ductus and pulmonic stenosis	1
Patent ductus and dextrocardia	
Defect of I-V septum and coarctation of aorta	
Unspecified	

PHILADELPHIA. TABLE IX

DISTRIBUTION OF CERTAIN FINAL DIAGNOSES BY RACE

(No Chinese or Filipinos were examined)

	WHITE	NEGRO
Total number examined	828	207
Number resubmitted	138	33
Number rejected	690	174
Rheumatic valvular disease	458	111
Hypertension	146	54
Tachycardia	8	0
Neurocirculatory asthenia	52	2
Congenital heart disease	13	5
Syphilis of aorta (incl. aneurysm)	1	2
Coronary heart disease	0	0
Permanent auricular fibrillation	9	0
Paroxysmal tachycardia	0	0

PHILADELPHIA. TABLE X

MISCELLANEOUS DATA

No. of cases resubmitted with hypertension, believed to be of nervous origin	0
No. of cases resubmitted with tachycardia, believed to be of nervous origin	0
No. of cases resubmitted with unexplained (nonpathologic) apical systolic murmurs	21
No. of cases resubmitted with unexplained (nonpathologic) aortic systolic murmurs	0
No. of cases in which the ECG was the *deciding factor* in final rejection diagnosis (This does not necessarily mean it was the *only* finding, e.g., a systolic murmur also may have been present)	3
No. of cases in which x-ray of the chest was the *deciding factor* in final rejection diagnosis	9
No. of cases in which *original* rejection diagnosis (by local board or induction station) agreed with *final* rejection diagnosis of Special Board	602
No. of cases in which there was disagreement between original and final rejection diagnoses	262
No. of cases in which incomplete original diagnosis made comparison impossible	38
The three or more original rejection diagnoses with which the final diagnoses most frequently disagreed (in order of frequency of disagreement)	
1. Valvular heart disease	
2. Hypertension	
3. Tachycardia	

ADDENDUM FOR PHILADELPHIA RE-EXAMINATION REPORT

Of the 171 rejectees recommended for resubmission for examination at the Induction Center as probable 1A, 107 were accepted for military service by Aug. 19, 1943. There were 44 rejected and 20 not re-examined, for other reasons. The causes for the second rejection were as follows:

Hypertension		5 cases
Patent ductus arteriosus		1 case
Valvular heart disease (mitral)		1 case
Heart block		1 case
Occlusion of left brachial artery		1 case
Nervous and mental		14 cases
Miscellaneous		21 cases
Otitis media	3	
Hernia	3	
Defective vision	3	
Albuminuria	1	
Alcoholism	1	
Asthma	1	
Bronchitis	1	
Fistula in ano	1	
Fracture	1	
Obesity	1	
Stricture	1	
Syphilis	1	
Tuberculosis	1	
Stammering	1	
Osteomyelitis	1	

REPORT OF THE SAN FRANCISCO BOARD

WILLIAM J. KERR, M.D., CHAIRMAN

ORGANIZATION

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F. L. Chamberlain
J. K. Lewis
J. M. Read
J. J. Sampson
Paul Gliebe (Psychiatry)
Mayo H. Soley (Neurocirculatory asthenia)
Earl R. Miller (Roentgenology)
Resident Staff and interns in Medicine and Roentgenology

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Sylvia Posner
Barbara Saunders
Mildred Truett

Electrocardiograph
Jean Hitch
Ola Nagle
Evelyn Tiernan

X-ray
Emily Bacon
Esther Ross
Ione Shrader
Ann Temple

Laboratory
Fermer Lloyd

HOUSING AND TIME FOR OBSERVATIONS

WAITING rooms and examining rooms in Out Patient Department of the University of California Hospital.

Time of sessions: Monday, Wednesday, and Friday evenings, 7 to 10, or until finished.

Fluoroscopic unit, electrocardiographic laboratory, and clinical laboratory. Out Patient Department of the University of California Hospital.

X-ray film rooms, University of California Hospital, adjacent to Out Patient Department.

ARRANGEMENTS FOR EXAMINATIONS

Through the California State Selective Service headquarters, Sacramento, California, instructions were issued to the local boards in the San Francisco City and County, to "pull" the records of all draftees in 4F who had been rejected for cardiovascular diseases and who showed no other rejectable defects. A sergeant was assigned to serve temporarily with our Special Board to facilitate the study. Subsequently, the local boards in Oakland and Berkeley were instructed to do likewise to secure the total of more than 1,000 suitable records.

At frequent intervals, and at least ten days before the dates for appointments to report for examination, the Chairman met with the sergeant to go over individual records to make sure that no men were called with (1) other rejectable defects, (2) positive serological tests for syphilis, or (3) those who would reach the age of 38 years within a month of the time of examination.

Groups of 50 to 55 were called for the earlier examinations; later, 60 to 70 were called when it became apparent that a larger number could be examined efficiently.

Some difficulty was experienced in completing the electrocardiograms and roentgenograms on the evening of the examinations because the doubtful conditions required longer study and many of these accumulated toward the end of the evening. To obviate a return visit it was frequently necessary to keep the technicians and some of the secretaries until a late hour.

The Resident Staff were of great assistance in making some of the preliminary examinations to conserve the time of the chief examiners, especially in those subjects with tachycardia and hypertension requiring many observations. Incidentally, the opportunity for these assistants to see such a large and varied collection of cardiovascular conditions was of great educational value.

At the beginning of each session, subjects were passed rapidly through the fluoroscopic unit and then placed at rest in the examining rooms. Each examiner had three or more quiet rooms which we found important for proper observation and to provide space for prolonged rest when required for subjects with tachycardia or hypertension.

Consultations between examiners were frequent, and in all cases where a chief examiner thought the candidate had a doubtful lesion or one which would place him in the 1A group, one or more examiners verified the findings of the first examiner.

From the beginning, we were anxious to make special observations on three groups of subjects. We were particularly interested in noting the number of subjects with coarctation of the aorta. Our high incidence of this condition, in comparison with the findings of the other units, is striking; perhaps due in part to the higher relative incidence of congenital lesions in this geographic area. We had associated with

us an able psychiatrist who made special observations on those with persistent tachycardia and persistent hypertension, and a physician skilled in physiologic methods who made special observations on subjects with suspected neurocirculatory asthenia.

Most of our subjects were of the white race. The figures for the Negro race are not immediately available but they constituted a negligible group for statistical purposes.

During the early part of the examinations the standards of acceptance were those specified by the Selective Service instructions MR 1-9. Following the receipt of a memorandum of decisions from the Boston Unit, February, 1943, we adopted a more liberal attitude concerning tachycardia and hypertension, namely, maximum levels of 110 for the pulse rate and 160/95 for blood pressure readings. We recalled all the borderline cases previously examined and accepted a number of those who would have been otherwise rejected.

A total of 983 subjects were examined. Of these, 24 were found to have no cardiovascular abnormality but had other defects which were specified for the benefit of the local draft boards. These clinical conditions are listed, and these 24 subjects have been counted in compiling our statistics, in view of the fact that they were originally rejected for cardiovascular disease where no rejectable cardiovascular disease was found to exist, and because we may have overlooked other rejectable noncardiovascular disease which may be found subsequently at induction centers.

RESULT OF THE EXAMINATIONS

The results of the examinations are tabulated as follows:

Total number examined	983	
Number accepted	275	= 28.0 per cent of total
Number accepted as to cardiovascular system but rejected for other defects	24	= 2.4+ per cent of total
Number rejected for cardiovascular defects	684	= 69.5+ per cent of total

A table showing comparative figures for draftees rejected by local boards and induction centers and results of our examinations includes 24 men accepted for cardiovascular status but rejected for other causes.

Rejected by local boards and medical advisory boards	420	
Accepted by our board	181	= 43.1 per cent
Rejected by induction centers	563	
Accepted by our board	117	= 20.78 per cent

The diagnoses of the specific clinical status of the entire group of 983 have been arranged alphabetically in Table II and the comparison of our findings with those of the local draft boards and the induction centers is shown.

The data of our examination have been arranged and grouped in Tables I, II, and III.

SAN FRANCISCO. TABLE I

	REJECT	ACCEPT
Syphilitic aortitis presumptive—positive history, negative serology test	2	
Valvular heart disease, all types	297	
Recent history of rheumatic fever	3	
Hypertension	202	
"Nervous hypertension"		31
Tachycardia	17	
"Nervous tachycardia"		19
Neurocirculatory asthenia	19	
Anxiety neurosis	6	
Angina pectoris	1	
Myocardial infarction	1	
Pericarditis	3	
Physiologic or functional murmurs		89
Systolic click		3
Congenital heart disease (total 60):		
Coaretation of the aorta	8	
I-V septal defect	25	
Patent ductus Botalli	9	
Pulmonary stenosis	1	
Interauricular septal defect	1	
Other congenital defects and mixed	16	
Enlargement of heart by x-ray beyond acceptable limit without other defects	26	
Thromboangiitis obliterans	2	
Heart displaced by pulmonary disease	1	
Funnel breast with displaced heart	2	
Poor training		2
Hyperthyroidism	1	
Nephritis	2	
Borderline cardiovascular disease, combination of clinical findings, x-ray, and electrocardiographic changes	8	
Disturbed mechanisms and arrhythmias:		
Auricular tachycardia (paroxysmal) chiefly on verified history	5	
Auricular flutter (secondary diagnosis)	1	
Auricular fibrillation	2	
A-V heart block	4	
Bundle branch block	2	
Sensitive carotid sinus	1	
Vagotonia	1	
Cardiovascular system within normal limits, based on criteria		130
Noncardiovascular defects	24	
Electrocardiographic abnormalities (primary cause of rejection)	12	

DISCUSSION OF RESULTS OF THE EXAMINATION

The chief difficulties encountered in the examinations were concerned with decisions in subjects with murmurs, tachycardia, and borderline hypertension. Many subjects who showed moderate or marked elevation of the pulse rate showed *systolic murmurs,* chiefly over the third left intercostal space near the sternum and transmitted along the course of the pulmonary artery. After rest and relaxation, many of these murmurs decreased in intensity or disappeared. In a few subjects with

SAN FRANCISCO. TABLE II

DIAGNOSIS	DRAFT BOARD AND INDUCTION CENTER DIAGNOSIS		OUR DIAGNOSIS		REJECT	ACCEPT
	PRIMARY	SECONDARY	PRIMARY	SECONDARY		
Entire group—982					684	274 + 24
Angina pectoris	1	1	1	1	1	
Auricular fibrillation	1	1	2	2	2	
Auricular flutter				1		
Anxiety neurosis	3	2	6		6	
A-V heart block	3		4	5	4	
Buerger's disease	2		2		2	
Bundle branch block			2		2	
Carotid sinus			1		1	
Combination of borderline abnormalities			8		8	
Congenital heart:						
Coarctation			7 + 1 ?		8	
I-V septal	2		25 + 5 ?	1	25	
Patent ductus	1		9		9	
Pulmonary stenosis	1		1		1	
Others	13		16	1	16	
Auricular septal			1		1	
ECG abnormalities	2		12	9	12	
Enlargement by x-ray	11	1	26	1	26	
Enlargement without x-ray	28					
Heart displaced by lung disease			1		1	
Hypertension	278	4	202	10	202	
Funnel chest			2		2	
Hypertension, nervous			31			31
Myocardial disease	19					
Myocardial infarction	1		1		1	
Neurocirculatory asthenia	10		19	11	19	
Nephritis	9		4		4	
Premature beats	2	1	3	4		
Pericarditis	4		3	1	3	
Physiologic murmur			89			89
Poor training			2			2
Rheumatic fever	5		3		3	
Systolic click			3			3
Tachycardia	76	8	17	9	17	
Tachycardia, paroxysmal	5		5	1	5	
Tachycardia, nervous			19	2		19
Syphilitic aortitis	1		2		2	
Vagotonia			1			1
Valvular heart disease:						
Aortic regurgitation	16		71 + 2 ?	6	73	
Aortic stenosis	3		13	27	13	
Aortic insufficiency and mitral stenosis	3		54		54	
Mitral regurg.? etiol.	104		62	1	62	
Mitral regurg., rheumatic	10		26		26	
Mitral stenosis with or without regurgitation	35		63	3	63	
Valvular heart disease	307		6		6	

flat chests these murmurs persisted, and if they remained loud, we were inclined to reject the subject although we are of the opinion that they are of no clinical significance. Cardio-respiratory murmurs were observed frequently and a notation was made on the record of the type, for the benefit of the examiners at the induction centers. Systolic murmurs at the apex, without history of rheumatic fever or scarlet

SAN FRANCISCO. TABLE III

DIAGNOSIS	DRAFT BOARD AND INDUCTION CENTER DIAGNOSIS		OUR DIAGNOSIS		REJECT	ACCEPT
	PRIMARY	SECONDARY	PRIMARY	SECONDARY		
Accepted for cardiovascular status, rejected for:						
Alcoholism			1		1	
Asthma			2 ?		2 ?	
Epilepsy				1		
Homosexuality			1		1	
Hyperthyroidism		6	2	1	2	
Hypopituitarism				1		
Hernia, inguinal			1		1	
Illiteracy				1		
Lymphoma			1 ?		1 ?	
Mental defective			2		2	
Psychoses			4		4	
Psychoneurosis			1		1	
Psychopathic inferior			1		1	
Tuberculosis			5+3 ?		5+3 ?	

fever, with no evidence of enlargement by physical examination or by x-ray, without electrocardiographic changes, and with no other evidence of cardiac disease, were accepted. Many of these murmurs varied with respiration or posture and were considered of no clinical significance. Mid-systolic murmurs or late systolic clicking sounds at the apex were not considered cause for rejection, in the absence of other evidence of cardiac disease. In a very few instances where such murmurs were very loud in any posture, the subjects were rejected, in view of the probability that, if detected during febrile states or at other examinations, a diagnosis of serious heart disease would be made on the murmur alone.*

Persistent tachycardia and other symptoms and signs generally grouped under the syndrome of neurocirculatory asthenia were frequent causes for rejection by the local boards and at the induction centers. It should be stated that the acceptable limit for the pulse rate had been raised to 110 per minute for our examination, which explains in part the discrepancy on figures for rejection. Between 75 and 100 men have been referred with a diagnosis of neurocirculatory asthenia. It has been obvious in going over this special group that the criteria for making this diagnosis vary widely.

Persistent hypertension was found in our group of subjects in about the same ratio as among all the other groups studied in eastern cities.

X-ray Examination.—The Hodges-Eyster formula for cardiac size appears to be generally acceptable, but in a number of cases a strict

*We were particularly struck with the relatively small number of subjects who had definite evidence of valvular heart disease, including rheumatic heart disease. We have long known that rheumatic fever was relatively uncommon in the Bay region and in other sections of California, but rheumatic heart disease has been known in subjects who had no history of rheumatism. In going over this group of subjects, we made it a point to question a number of them about their residence at the time when they had rheumatic fever, or first had any mention made of valvular heart disease, and found that quite a large number of these young men had their disease begin while they were living in other sections of the country. We are now making a survey of the whole group to find out, if we can, when and where they first had signs or symptoms of valvular heart disease or rheumatic fever or chorea. We may get some interesting data from this study.

application of the rule would exclude some normal subjects. Dr. Earl R. Miller, roentgenologist, has summarized his observations on the roentgenologic examinations and I am incorporating his comments:

"From the radiologist's point of view, it would seem that the best way to examine rejectees from the draft would be by a survey of all of the rejectees by single 14 by 17 posteroanterior films of the chest. This has the advantage of being an objective measure of heart size and shape, to which any of the accepted criteria for heart size could be applied.

"I believe the Hodges-Eyster method of measurement is perhaps as good as any, inasmuch as it is about as objective as it can be, and because it takes into account much more of the patient's build than the cardiothoracic ratio. In addition, the film of the chest demonstrates other conditions, such as lesions in the lung, which would make the person unfit for military service. In questionable cases, fluoroscopy should be added. Fluoroscopy, alone, has the very marked disadvantage of being a subjective record and therefore its validity is open to doubt.

"It is frequently argued that the cost of such an undertaking as mass film surveys of people is very expensive. I think it is quite obvious that the expense of such a survey is very much less than the cost of the care of patients missed by failing to make such a survey.

"In addition, this record would be of inestimable value to the patients themselves for comparison in future years when other diseases make their appearance.

"It would seem to me that a little leeway should be allowed in rejecting patients for heart size when their heart is apparently slightly above normal in size and all other things appear to be within normal limits. It would seem that a strict application of some rules about size does not always allow a correct interpretation of the cardiac status."

Electrocardiography.—We had a number of electrocardiograms of individuals who seemed to be entirely normal and whose cardiac sounds were either normal or showed so-called functional murmurs where the electrocardiogram showed prolongation of the P-R interval to a 0.22 second or more, and in some instances to 0.24 second in one or two leads. We had some difficulty in evaluating this finding and we are keeping these records together for special study in the near future. We hope to be able to follow these subjects for some time.

Several of the chief examiners have submitted a number of observations which are incorporated as follows:

1. *Dr. Edwin L. Bruck.*—"I think the regulations for examination of selectees should be made most carefully by cardiologists, and that all doubtful murmurs should be submitted to unusual scrutiny, for I am sure that many of the murmurs which have rejected young men from the Armed Forces are not important in so far as cardiac pathology is concerned. Further clarification in the regulations, as well as in the minds of many examiners for the Army and Navy, is going to be necessary before proper acceptance or deferment of individuals with heart murmurs can be made. Not only the so-called functional murmurs but

also questionable murmurs should be examined with the utmost scrutiny, and other examinations of the heart should be carried out in greater detail, because we are sure that many of these murmurs may come from mild congenital defects or unimportant large vessel changes and have no significance when the heart is normal from the standpoint of x-ray, electrocardiography, vital capacity, exercise tests, pressure, pulse rate, etc.

"The determination of the size of the heart by ordinary clinical methods of percussion and palpation, as against the x-ray examination, is always a surprise to me. That is, I am surprised that the two methods of examination coincide so often. There is no substitute, of course, for proper x-ray examination, but the evaluation of heart size from x-ray examination is sometimes difficult. According to formula, we saw many hearts which were large by that method and within the normal range of size by all other methods. Many times these were on the basis of formula or the nomogram in which the height and weight of the individual were abnormal in proportion. That is, very tall, thin people were apt to be construed as having hearts that were enlarged when, by all other methods, they were within the normal range.

"As to the matter of rapid pulses with normal sinus rhythm, the nervous influence must be a very large one in this group of men, engendered by either one of two fears. The fear of being taken into the Army when they do not want to go or the fear of being left out when they do want to go. I do not believe that these conditions can be classified as cardiac neurosis or neurocirculatory asthenia without a number of other findings which were lacking in most instances. This group deserves further examination and further study."

2. *Dr. J. Marion Read.*—"We found a great many patients who actually had normal blood pressures and who had been 'tagged' as hypertensives. Of course, the same was true to a certain extent in many of the subjects with murmurs, but I was particularly struck by the former. It is difficult to explain this situation. Probably many of the subjects were 'pepped up' and a little hypertonic at the time of their first examination, but were not really hypertensives."

3. *Dr. J. K. Lewis.*—"With reference to heart size by x-ray, I feel that the present allowable limits might be increased with safety. I would suggest a further study of the rejected group, particularly the borderline cases and those in whom an exact diagnosis could not be made."

4. *Dr. David A. Rytand* (Dr. Rytand substituted for Dr. J. K. Lewis).—"I was impressed, as might have been expected, by gross inequalities in the general level of practicing physicians; heart disease diagnosed when not present, on the one hand, as against the number of patients with coaretation who knew what was wrong with them. I am not yet convinced that men should be rejected because their arterial pressures are a few millimeters over certain arbitrary standards. Likewise, I feel we pay too much attention to lone systolic murmurs (except at the base) and to their transmission."

5. *Dr. F. L. Chamberlain.*—"In the draftee examination research, I doubted the accuracy of the x-ray heart measurements according to the Eyster formula. It would be very helpful if the patients rejected because of heart size could be followed over a period of years.

"I felt that there was considerable difference of opinion among members of our Board with respect to the interpretation of murmurs. Accordingly, if a future study is done, I believe standards should be

agreed on in an early 'skull session' in which criteria could be agreed upon.

"I commend the study especially for its educational value to members of the Board as well as to visiting house officers."

RECOMMENDATIONS

It is my opinion that in this region of the country the number of reclaimed men of draft age was great enough to make the undertaking worth while. The relatively low incidence of valvular heart disease is in striking contrast with the experience in the other four cities where similar examinations were conducted.

If a sufficient number of qualified cardiovascular examiners were available, similar surveys could be made in all the larger centers of population in the country. However, it is my opinion that enough qualified examiners could not be recruited at this time to make these examinations. Alternative plans would be (1) to strengthen the staffs at the induction centers by the inclusion of highly qualified specialists in this field and other fields, or (2) to use the services of cardiovascular specialists wherever possible as consultants for the induction centers. There is apparently a reservoir of men who have been placed in the 4F category by the examiners at the local board with or without the advice of Medical Advisory Boards, and, unless they are re-examined by competent physicians, these men will remain in the 4F category indefinitely.

It is the hope of our special examiners that we may be able to follow some of the groups of subjects who had conditions of unusual interest. We would like to know more about the subsequent course in patients with hypertension and tachycardia. We are interested in the psychological aspects of both of these problems. In subjects who have borderline conditions and are accepted for full military service, it would be desirable to have the serial numbers of these men so that we may be able to follow their course in the years to come. The serial numbers could be affixed to our records and follow-up studies could be made through the special examiners who have participated in this study. A number of our subjects who had borderline tachycardia or hypertension have been accepted for service, which increased our percentage of those placed in the category of 1A, whereas in other studies a number of these were probably excluded from service. I am of the opinion that those with slight hypertension probably will make better soldiers under trying and difficult conditions than the average, whereas those who had effort syndrome or neurocirculatory asthenia probably would develop the picture of so-called shell shock at the first opportunity.

All those physicians who participated in our examinations on a voluntary basis did so gladly and with a fine spirit of cooperation. Those who received compensation for their services likewise devoted themselves wholeheartedly to their tasks after long and arduous days at the hospital.

A DETAILED ANALYSIS OF THE ELECTROCARDIOGRAMS OF 500 R.C.A.F. AIRCREW

SQUADRON LEADER C. B. STEWART AND
FLIGHT LIEUTENANT G. W. MANNING

IN A previous report[5] a gross analysis was made of the wave complexes and time relationships of the electrocardiograms of 2,000 Royal Canadian Air Force aircrew between the ages of 18 and 32 years. The present report contains a more detailed analysis of an additional 500 electrocardiograms showing the variation in form, amplitude, and time relationships of the wave complexes.

The characteristics of the normal electrocardiogram are described in most textbooks or physiologic treatises on cardiology, but the authors differ somewhat in their definitions of the degree of variation to be expected in healthy individuals. Almost all of them set definite limits for the so-called "normal range" of amplitude or duration of each complex or interval. Occasionally, these standards are based on the study of a small number of electrocardiograms, or are admitted to be arbitrary, but more frequently the number of individual records is not stated. An exact determination of the range of amplitude or duration of certain complexes is largely of academic interest, but the establishment of significant standards for the complexes or intervals which are of chief diagnostic aid is of considerable practical importance.

In textbooks published within the last ten years, the limits of the normal P-R interval are variously defined as 0.12 to 0.18 second by Lewis;[6] 0.13 to 0.16 second with 0.21 second as the extreme limit of normal by Wright;[14] 0.12 to 0.20 second by White,[12] by Graybiel and White,[4] and by Maher and Wosika;[7] less than 0.20 second by Master[9] and by Carter,[2] and with upper limits varying from 0.16 to 0.21 second depending upon body size and the heart rate by Ashman and Hull.[1]

The normal limits of R wave amplitude in the lead showing the greatest deflection are described as 4 to 16.5 mm. in 52 normal adults, by Lewis;[6] 5 to 35 mm. by White,[12] and by Graybiel and White;[4] 4 to 22 mm. by Ashman and Hull;[1] 7 to 15 mm. by Master,[9] and 5 to 20 mm. arbitrarily accepted as the normal range by the Criteria Committee of the New York Heart Association[3] and by Maher and Wosika.[7]

Lewis[6] states that the P wave is always positive in normal young adults in all leads, but Ashman and Hull[1] report that a negative P wave occurs normally on rare occasions in Leads I and II, and that a negative or diphasic P_3 occurs in 4 to 5 per cent of normal records. White[12] states that inversion of the P wave is abnormal in Lead I, except in

congenital dextrocardia, and always in Lead II. Carter[2] also defines a negative P_2 as a definite abnormality.

White,[12] in 1931, stated that T_1 and T_2 are always upright in normal electrocardiograms unless the record is taken during forced respiration, but later, in 1941, he found, with Chamberlain and Graybiel,[13] that inversion of the T waves in Lead II may occur normally as the result of positional and sympathetic nerve effects. Ashman and Hull[1] report a few cases in which T_2 was inverted in the absence of heart disease.

Similar and even more marked discrepancies occur in the definitions of deviation of the electrical axis of the heart. White[12] defines the normal axis deviation as 0 to 90 degrees when plotted on the Einthoven triangle. The Criteria Committee of the New York Heart Association[3] set 30 to 90 degrees as the normal range when their standards are expressed in the same scale, while Ashman and Hull[1] define the limits of normality as 40 to 90 degrees.

When a limited group on either side of the average is labeled the "normal range" for the amplitude or time interval of any electrocardiographic complex, the inference is that measurements outside that range are abnormal, although in practice they sometimes do not indicate any definite cardiac abnormality. Different methods have been used by different cardiologists in setting the limits which they describe as the normal range. Few writers define the system which they follow, but it is obvious that two are used. By some, the normal zone is so widely defined as to include some borderline abnormals as well; by others the zone of greatest distribution is accepted as the normal, excluding the more extreme and less frequent normal variations. With the wide range, one would correctly label as abnormal any measurements beyond the established limits, provided the standards had been based on a true random sample of the normal population, and adequate provision had been made for chance variation beyond those observed limits. In many reports, however, no statistical tests have been applied to determine the chance variation beyond the limits recorded in that particular series of observations. With the narrower definition, certain borderline normal electrocardiograms will be incorrectly placed in the abnormal class. Obviously, the narrower the limits are made, the more cases will be wrongly excluded from the normal group.

In some instances, limits of normality are defined but at the same time completely disregarded. For example, it seems paradoxical to state, as one writer does, that the upper limit of normality of the P wave is 1, 2.5, and 2 mm., in the three standard leads respectively, and to follow this with a statement that the increase in height beyond these limits is not an adequate basis for a diagnosis of abnormality.

It would probably be preferable to eliminate the use of the terms "normal" and "abnormal" and to accept such terms as "of no significance," "of slight significance," or "of definite significance," de-

pending upon the degree of deviation from the average picture. In practice, the cardiologist assesses the clinical importance of any electrocardiographic peculiarity on this basis, considering both the degree of aberration from the so-called normal range and the presence or absence of associated clinical, radiological, or other electrocardiographic abnormalities. In the absence of other findings, an electrocardiographic measurement slightly beyond what is usually accepted as the normal range is considered of slight significance, such as a P-R interval of 0.22 second. However, a P-R interval of 0.40 second, which is definitely beyond this range, may alone be considered of diagnostic significance.

There is undoubtedly an overlapping of the normal and abnormal in the electrocardiogram as in most measurements relating to human physiology, and the setting of exact limits of normality is impossible. After an attack of rheumatic fever an individual may have had an increase in the P-R time from 0.14 to 0.20 second due to an organic interference with the conduction mechanism, while a normal individual occasionally may have a P-R interval of 0.22 second with no history of cardiac illness, no clinical abnormalities, and no sequelae to suggest heart disease. Rather than accepting one rigid standard in preference to another, it seems desirable, therefore, to set the extreme limits of normal beyond which no normal electrocardiogram would be expected to occur and to provide some index of the possibility of normals or abnormals occurring at various levels below these limits.

In this report, data are presented to show the variation to be expected in the electrocardiograms of a comparatively large group of healthy young male adults. By use of the standard deviation of the mean, in numerical data conforming to the normal curve of distribution, the limits can be determined at which deviations from the average become slightly or definitely significant. If three times the standard deviation is added to, or subtracted from, the average measurement, the upper and lower limits of the distribution are obtained with an error of approximately 0.3 per cent. In other words, there would be only about three chances in a thousand of finding a measurement greater than the upper limit or less than the lower limit in the electrocardiogram of a healthy man of this age group. One would be well justified, then, in calling abnormal any measurement which fell beyond three times the standard deviation. By adding or subtracting twice the standard deviation, one obtains the limits which may be accepted as those of practical significance. Less than 5 per cent of normal electrocardiographic measurements will fall above or below these limits. If a measurement falls between two and three times the standard deviation, one would have to be particularly careful to seek corroborative clinical or other data before considering the electrocardiographic finding significant. This method gives information as to the full limits of the normal range, and the limits in which corroborative evidence is

necessary to determine significance. It also permits an estimate of the chance of error in calling a borderline electrocardiogram normal or abnormal. Calculation of the standard error of the mean gives an indication of the degree of error in accepting the mean of this series of five hundred as indicative of the mean of an unlimited group of normal young men.

MATERIAL AND METHODS

The present series of electrocardiograms were taken on 500 R.C.A.F. aircrew trainees between the ages of 18 and 32 years, the majority being between the ages of 18 and 26 years. All had passed the standard R.C.A.F. medical examination for "Fitness for Flying" at a recruiting center, and had had a complete medical recheck at the time that the electrocardiograms were recorded. In addition, those who showed questionable or definite electrocardiographic abnormalities were again rechecked clinically and, in many cases, by further electrocardiographic records. Although x-ray plates had been taken on all individuals on enlistment, additional plates were taken in many cases to recheck cardiac measurements.

A portable Cambridge (English) electrocardiograph was used, making a record on a single film of five seconds' duration for each of the three leads. The subject rested for approximately five minutes in the recumbent position before the recording was made. The three standard leads were used, the deflection of the galvanometer string being standardized before each lead (1 cm. – 1 mv.). Measurements of the amplitude of waves were made to the nearest 0.2 mm. from the top of the base line in positive waves and from the bottom in negative waves. Time intervals were measured to the nearest 0.02 second along the bottom of the base line for positive waves and the top of the base line for negative waves. The repetition of those records which showed various abnormalities provided a check on the recording technique and showed that the records were duplicated with a high degree of accuracy in all significant details.

There had been no change in the medical standards employed in the selection of this group and of the 2,000 whose electrocardiograms were previously reported, nor in the age grouping of the men.

A comparison of the data obtained in the analysis of the electrocardiograms of the present series and the previous group of 2,000 is shown in Table I.

There are no statistically significant differences between the two groups in the above measurements nor in other measurements made according to the same standards of accuracy in both series. It may be concluded from the close similarity of the data in the two groups, that the series of 500 is as representative a sample of the aircrew population as the larger one of 2,000 men.

TABLE I

COMPARISON OF PRESENT 500 ELECTROCARDIOGRAMS WITH 2,000 PREVIOUSLY REPORTED[5]

		SERIES OF 2000 ECG		SERIES OF 500 ECG	
		NO.	PER CENT	NO.	PER CENT
Category 1		27	1.35	9	1.8
Category 2		358	17.90	66	13.2
Category 3		1307	65.35	331	66.2
Category 4		299	14.95	92	18.4
Category 5		9	0.45	2	0.4
		2000	100.00	500	100.0
Positive P wave	(Lead I)	1973	98.60	497	99.4
	(Lead II)	1962	98.10	497	99.4
	(Lead III)	1581	79.00	401	80.2
P-R interval between 0.12-0.20 second	(Lead II)	1949	97.45	484	96.8
R wave over 5 mm.	(Lead I)	1236	61.80	311	62.2
	(Lead II)	1964	98.20	492	98.4
	(Lead III)	1468	73.40	371	74.2
Positive T wave	(Lead I)	1997	99.85	500	100.0
	(Lead II)	1989	99.45	499	99.8
	(Lead III)	1425	71.25	356	71.2

TABLE II

DIRECTION AND AMPLITUDE OF P WAVE

DIRECTION					AMPLITUDE IN MM.				
LEAD	POS.	NEG.	DI-PHASIC	AB-SENT	MEAN AMP.	STANDARD DEVIATION OF MEAN	STANDARD ERROR OF MEAN	SIGNIF. LIMITS (± 2 S.D.)	HIGHLY SIGNIF. (± 3 S.D.)
I	497	0	0	3	0.7	0.28	0.01	0.1 to 1.3	−0.1 to +1.5
II	497	0	1	2	1.4	0.53	0.02	0.3 to 2.5	−0.2 to 3.0
III	401	48	41	10	0.7	0.59	0.03	−0.5 to +1.9	−1.1 to +2.5

ANALYSIS OF DATA

P Waves.—Table II shows the direction and amplitude of the P waves in 500 electrocardiograms.

None of the records showed consistently negative P waves in Leads I and II, but occasional negative complexes appeared in a few records as a result of auricular extrasystoles. Only one record showed diphasic P waves in Lead II. The P wave was negative in Lead III in forty-eight records (9.6 per cent) and diphasic in forty-one others (8.2 per cent).

The amplitude of the P waves of the 500 records followed the normal curve of distribution with less than 5 per cent of the total falling outside limits set by twice the standard deviation (2.4 per cent in Lead I, 4.2 per cent in Lead II, and 3.8 per cent in Lead III). Only four records showed a maximum P wave in excess of 2.5 mm. in Lead II, and none had P waves of less than 0.5 mm. in all three leads. Slight varia-

tions were frequently noted in the amplitude of the P wave throughout a lead, and in twelve records this variation amounted to 0.5 to 1.5 mm. difference between the maximum and minimum complexes. In two records P_3 changed from a low positive wave to diphasic to negative and back to positive. The variations in amplitude were probably associated with the respiratory cycle.

Table III shows the average duration of the P wave in the three leads.

TABLE III

DURATION OF P WAVE

LEAD	MEAN P TIME	STANDARD DEVIATION OF MEAN	STANDARD ERROR OF MEAN	SIGNIF. LIMITS (± 2 S.D.)	HIGHLY SIGNIF. LIMITS (± 3 S.D.)
I	0.08	0.018	0.0008	0.04 to 0.12	0.03 to 0.13
II	0.09	0.015	0.0007	0.06 to 0.12	0.05 to 0.14
III	0.08	0.018	0.0007	0.04 to 0.12	0.03 to 0.13

Broad P waves, defined by the Criteria Committee of the New York Heart Association as those of more than 0.10 second, were present in twenty records in Lead I, in thirty-seven records in Lead II and in twelve records in Lead III. Only one of these records showed broad P waves in all three leads and ten others in two leads. The point at which P wave duration is significantly prolonged would seem from this series to be 0.12 second.

Although P waves of very low amplitude also tended to be of short duration, there was only a low positive correlation of 0.31 in the whole group between wave amplitude and duration. Waves of high amplitude might be either of relatively short duration or slow and broad.

Table IV shows the number of records which had a rounded, pointed, or notched P-wave summit.

TABLE IV

SHAPE OF P WAVE

LEAD	P ROUND	P POINTED	P NOTCHED	OCC. POINTED WAVE
I	466	15	17	--
II	417	49	27	5
III	419	38	19	4

The majority of the P waves formed a rounded summit, but a considerable number of records showed a sharp or pointed P wave, and over 5 per cent were notched in varying degree at the apex. Five records in Lead II and four in Lead III showed varying sharp and rounded P-wave complexes. The notching was not correlated with extremes of P-wave amplitude or duration, nor with any other electrocardiographic peculiarity, and it did not usually occur in all leads of a record.

P-R Interval.—The P-R interval was measured in all three leads from the beginning of the P wave to the beginning of the QRS com-

plex, whether positive or negative. The average duration was calculated from these measurements, but, if the interval was borderline or prolonged in any lead, allowance was made for an absent or isoelectric Q wave as recommended by Graybiel and White.[4]

Table V shows the average duration of the P-R interval in each lead, the standard deviation from the mean, and the calculated limits of the distribution.

TABLE V

P-R INTERVAL

LEAD	MEAN P-R DURATION	STANDARD DEVIATION OF MEAN	STANDARD ERROR OF MEAN	SIGNIF. LIMITS (± 2 S.D.)	HIGHLY SIGNIF. LIMITS (±3 S.D.)
I	0.15	0.026	0.001	0.10 to 0.20	0.07 to 0.23
II	0.16	0.025	0.001	0.11 to 0.21	0.09 to 0.24
III	0.15	0.027	0.001	0.10 to 0.20	0.07 to 0.23

The incidence of P-R intervals of different durations formed a normal curve of distribution on either side of the mean. The average duration and limits of the P-R distribution were slightly greater in Lead II than in the other leads, the limits as set by twice the standard deviation being 0.11 second to 0.21 second. However, 1.4 per cent of this group of healthy young men had electrocardiograms with a P-R interval of more than 0.20 second in Lead I, 2.2 per cent with P-R greater than 0.21 second in Lead II, and 1.8 per cent with P-R greater than 0.20 second in Lead III. Of these, 0.6 per cent had a P-R in excess of 0.24 second, the upper limits of normal set by three times the standard deviation of the mean.

It cannot be stated with absolute certainty that these individuals with apparently prolonged P-R intervals were normal, but careful clinical history and examination and radiological study revealed no evidence of cardiac disease. It would appear from the above statistical data that approximately this number of normal young men might be expected to have P-R intervals greater than 0.20 second. However, this does not prove that these men will not later develop definite evidence of cardiac disease associated with poor conduction of the cardiac impulse. At present, however, they are apparently normal, athletic young men with good cardiac function, and the electrocardiographic evidence of prolonged P-R interval seems not to be significant.

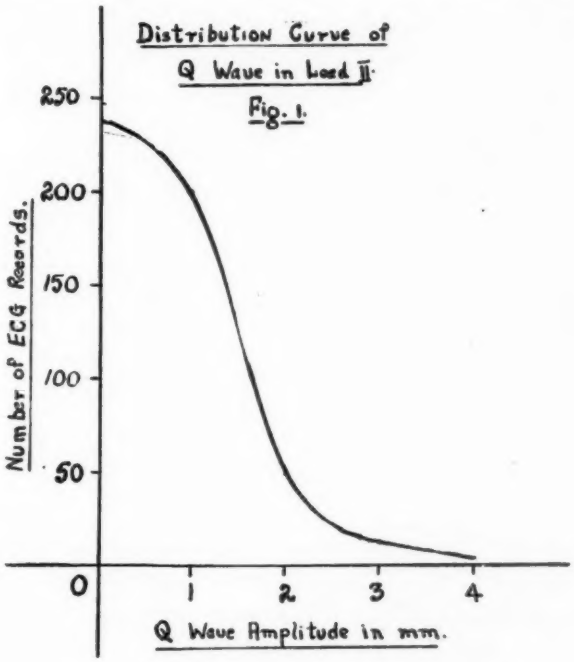
The four men whose electrocardiographic records showed P-R intervals of more than 0.24 second were also apparently normal young men with no abnormality except the long P-R conduction time of 0.26, 0.26, 0.32, and 0.36 second, respectively. The electrocardiographic records of these men are discussed more fully in another paper.[8] If these extreme P-R measurements are excluded from the series, the calculated mean and the standard deviation are not reduced to any significant degree.

Slight depression of the P-R segment below the isoelectric line was common but it exceeded 0.5 mm. in only nine records. It occurred in all three leads in six cases and in only Lead II in three others, and probably represented the auricular T wave.

TABLE VI

Q-WAVE AMPLITUDE

LEAD	Q PRESENT	Q ABSENT	MEAN AMP.	OBSERVED RANGE (IN MM.)
I	143	357	0.9	0 to 4
II	290	210	1.1	0 to 4
III	305	195	1.4	0 to 6



Q Wave.—Table VI shows the incidence of Q waves and their average amplitude in the series of 500 electrocardiograms.

The distribution of the Q-wave amplitude was not according to the normal curve, and limits set by the standard deviation would be misleading. The observed extremes are noted in each lead. Fig. 1 shows the curve of distribution of the Q-wave amplitude in Lead II, the other leads being similar.

Measurements of the Q wave alone are of little value unless compared with the maximum R-wave deflection of the same record. A Q wave is considered abnormally deep according to the standards of the Criteria Committee of the New York Heart Association[3] if Q_1 is greater than 15 per cent of the largest QRS deflection in any lead, Q_2 greater

than 20 per cent, and Q_3 greater than 25 per cent. These criteria do not hold in electrocardiograms showing a high voltage of the QRS group or for Leads II and III if there is right axis deviation. In defining a deep Q_3, Pardee[10] also excluded records which had an S wave in the QRS_3 complex.

The distribution of the percentage relationship of the Q waves present in Lead II to the maximum R is shown in Fig. 2. In the other leads the distribution was almost identical.

The majority of the records had a Q-wave amplitude which was less than 10 per cent of the maximum R, but a small number exceeded 20 per cent. Table VII presents data on the Q waves which showed a high percentage relationship to the maximum R.

TABLE VII

DEEP Q WAVES

RECORD NO.	MAXIMUM R WAVE	Q WAVE AMPLITUDE			PERCENTAGE RELATION OF Q WAVE TO MAXIMUM R	NORMAL LIMITS	AXIS DEVIATION (DEGREES)	S WAVE (AMP.)
		LEAD I	LEAD II	LEAD III				
1	R_1 9	2			22.2	15	66	2.5
2	R_1 11	2			18.2	15	19	3
3	R_1 12	3			25.0	15	3	2
4	R_2 13	4			30.8	15	40	0
5	R_1 12	2			16.6	15	10	0
6	R_1 8.5	1.5			17.7	15	30	1
7	R_2 18.0		4		22.2	20	95 RAD	0
				6	33.3	25	95 RAD	0
8	R_2 19		4		21.0	20	95 RAD	4.5
				5	26.3	25	95 RAD	1
9	R_3 11.5			3	26.1	25	87	0
10	R_2 9.5			3.5	36.8	25	65	0
11	R_2 12			3.5	29.2	25	87	0
12	R_3 7			2	28.6	25	38	2
13	R_1 5			1.5	30.0	25	15	3
14	R_3 7			2	28.6	25	97 RAD	0
15	R_2 17			4.5	26.5	25	93 RAD	0
16	R_1 8.5			3	35.3	25	59	0

This table shows that six records had Q_1 waves which were more than 15 per cent of the maximum R. Two Q_2 waves were more than 20 per cent of the maximum R. In Lead III ten records showed a Q wave which was more than 25 per cent of the greatest R amplitude. Two of these records had deep Q waves both in Leads II and III. None showed deep Q waves for all leads. None of the electrocardiograms had high voltage QRS, but four records showed a right axis deviation and were therefore excluded from the deep Q wave group by definition. Two others had borderline axis deviation of 87 degrees, but were included as deep Q waves. Two records which had S waves in Lead III would also be excluded according to Pardee's standards. Only twelve records, therefore, showed deep Q waves and had an axis deviation within the normal range. In these cases there were no other significant electrocardiographic abnormalities and the men were clinically normal in all respects.

R Waves.—The positive deflection of the QRS complex was considered as the R wave whether larger or smaller than the negative deflections. In a few records with more than one positive deflection, the maximum wave was included in this series as the R wave.

Table VIII shows the average amplitude, standard deviation, and range of the R wave.

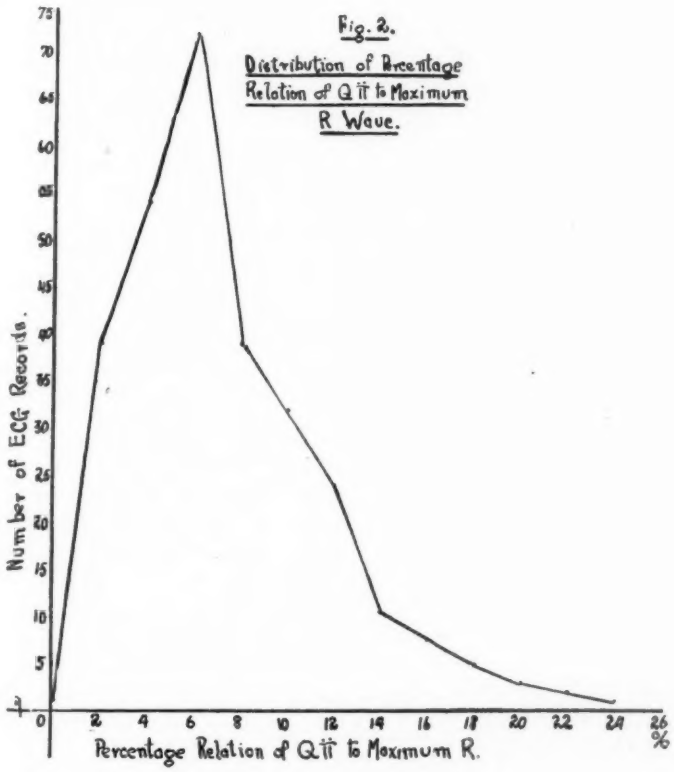


TABLE VIII

R-WAVE AMPLITUDE

LEAD	MEAN AMPLITUDE	STANDARD DEVIATION OF MEAN	STANDARD ERROR OF MEAN	SIGNIF. LIMITS (± 2 S.D.)	PER CENT ABOVE OR BELOW 2 S.D.
I	6.6	2.7	0.12	1.2 to 12.0	3.8
II	14.1	4.0	0.18	6.1 to 22.0	5.0
III	9.3	4.7	0.21	0.0 to 18.7	1.2

Two records had no positive wave in the QRS complex in Lead III. In the other leads R was present in all records. An R wave of less than 5 mm. amplitude occurred in 131 records in Lead I, in 7 records in Lead II, and in 103 records in Lead III. A number of these occurred in conjunction with right or left axis deviation, but there were a large number of records with normal axis deviation which showed low volt-

age of the R wave in Leads I and III. Only one record had R waves of less than 5 mm. in all three leads. On the other hand, 27 records in Lead II and one in Lead III showed an R wave in excess of 20 mm., the arbitrarily accepted standard of normality. The curves of distribution of the R-wave amplitude in Leads I and III are slightly skew, but in Lead II the distribution is normal. It is suggested from this curve that the upper range of significance might be set at 22 mm., and the lower at 6 mm. (S.E. ± 0.18) with extreme limits of normal of 2 to 26 mm.

In fourteen records there were two positive waves in the QRS complex of Lead III. This usually consisted of a small upright deflection of 1 to 2 mm. followed by a negative wave varying in amplitude from 1 to 8 mm. A second positive wave of 3 to 10 mm. amplitude was sometimes followed by a second negative wave of 1 to 3 mm. In most cases the first positive wave was very small and was followed by an apparently normal QRS complex. In a few records a small sharp upstroke of 0.5 to 1 mm. followed the S wave of what appeared to be a normal QRS complex. In some electrocardiograms a notching of the upstroke of the R wave near the base gave the appearance of an additional positive and negative wave preceding R, but the notch did not extend below the isoelectric line. In three records with additional positive waves there was an associated right axis deviation, the QRS consisting of a positive wave of 1 mm., a negative wave of 7 to 8 mm., and a second positive wave of 1 mm. This looked like an inverted QRS, but the P and T waves were positive.

A number of records showed slight variations in QRS amplitude throughout a lead, and two showed a marked change with the respiratory cycle from a low notched QRS_3 of 2.5 mm., to an unsplintered wave of 6 mm. amplitude.

S Wave.—The number of records showing S waves and the average amplitude are shown in Table IX.

TABLE IX

S-WAVE AMPLITUDE

LEAD	S PRESENT	S ABSENT	MEAN AMPLITUDE
I	432	68	2.8
II	382	118	2.5
III	265	235	2.3

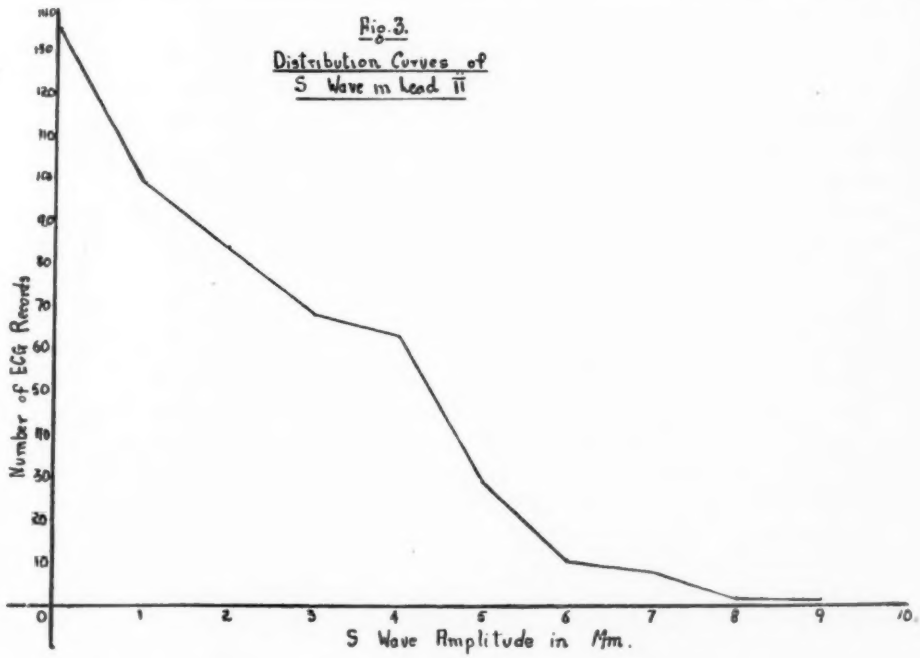
S waves were present in about three-fourths of the records with a mean amplitude of approximately 2.5 mm. Fig. 3 shows the curve of distribution of the S-wave amplitudes in Lead II. Since it is not a normal curve of distribution, the limits defined by the standard deviation from the mean are not calculated. Maximum S waves of 9 to 10 mm. occurred in three records, but the majority were 1 to 3 mm. in amplitude.

Slurred, Splintered, or Notched QRS.—The QRS complex showed varying degrees of slurring, splintering, or notching in 13, 4, and 130 records, in Leads I, II, and III, respectively. Two of the records showed slurring or splintering in all three leads and one in Leads II and III. This irregularity occurred nearer the apex of the QRS in some leads than in others in the same record, and would be considered an abnormal feature by some standards.[3] There was no consistent relation between slurring or splintering and other electrocardiographic abnormalities, although some of these records had a QRS interval which reached the maximum limits of normal. The individuals were all apparently normal clinically.

TABLE X

QRS INTERVAL

LEAD	MEAN DURATION	STANDARD DEVIATION	STANDARD ERROR	SIGNIFICANT LIMITS (± 2 S.D.)	HIGHLY SIGNIFICANT LIMITS (± 3 S.D.)
I	0.07	0.016	0.0007	0.04 to 0.10	0.02 to 0.12
II	0.07	0.016	0.0008	0.04 to 0.10	0.02 to 0.12
III	0.07	0.017	0.0007	0.04 to 0.10	0.02 to 0.12



QRS Interval.—The duration of the QRS interval is shown in Table X.

The upper limit of QRS time, in this series, as set by twice the standard deviation, corresponds with the usually accepted limit of 0.10 second. None of the records had a QRS time above this limit in Lead I, but five exceeded 0.10 second in Lead II, and six in Lead III. There was no

clinical abnormality associated with the finding of an increased QRS in these cases and this number might be expected to occur among normal young men. A QRS of more than 0.12 second might, however, be considered definitely abnormal.

T Wave.—The direction and amplitude of the T wave are shown in Table XI.

TABLE XI

DIRECTION OF AMPLITUDE OF T WAVE

	DIRECTION				AMPLITUDE					
LEAD	POSITIVE	NEGATIVE	DIPHASIC	ABSENT	MEAN AMP.	STANDARD DEVIATION OF MEAN	STANDARD ERROR OF MEAN	SIGNIF. LIMITS (± 2 S.D.)	PER CENT BEYOND SIGNIF. LIMITS	HIGHLY SIGNIF. LIMITS (± 3 S.D.)
I	500	0	0	0	3.0	1.0	0.04	1.0 to 5.0	3.4	0 to 6.0
II	499	0	1	0	3.8	1.4	0.06	1 to 6.6	3.8	–0.4 to 8.0
III	356	74	66	4	0.8	1.3	0.06	–1.4 to 3.4	4.2	–3.1 to 4.7

Twenty-eight per cent of the records showed diphasic or negative T waves in Lead III, but only one record had diphasic T waves in Lead II. The curve of distribution was a normal one with less than 5 per cent falling outside the limits set by twice the standard deviation.

U Wave.—U waves were present in 250 records in Lead I, in 274 records in Lead II, and in only 61 records in Lead III. Almost all of the U waves were of a very low amplitude, the average being approximately 0.2 mm.

RT-ST Segment.—The level of the RT or ST segment was measured to the nearest 0.2 mm. with relation to the post-T isoelectric line. In the majority of the records there was no measurable elevation or depression of the RT or ST segment. However, 77 records had a slight RT or ST elevation of 0.6 mm. in Lead I, and two other records showed a depression of 0.5 mm. Only one record had an RT elevation of more than 1 mm. in Lead I. Fifty-nine records in Lead II had an elevation of the RT-ST segment averaging 0.75 mm. Five of these showed an elevation in excess of 1 mm. (1.5 to 2 mm.). Thirty-four other records showed slight depression of the RT-ST segment of 0.8 mm., none of these exceeding 1 mm. In Lead III twenty-four records showed an elevation of the RT-ST segment averaging 0.6 mm. but none exceeded 1 mm. Seventy-nine other records showed a slight depression of the interval of 0.76 mm. and three of these were 1.5 mm. below the isoelectric line.

None of these records which showed a depression or elevation of the RT-ST segment exhibited any other significant electrocardiographic abnormality, and the men were clinically normal. Slight elevation or depression of the RT-ST segment of less than 1 mm. is not usually considered significant. It is possible that the above cases which showed an elevation or depression somewhat more than the accepted standards are

also of little significance, when not associated with T-wave changes or other peculiarities in the electrocardiographic complexes.

There was considerable variation in the level at which the R or S wave began to thicken and slope into the ST segment. In Lead I three records showed a slightly high take-off of 2 to 2.5 mm. and two showed a low take-off of 1.5 to 2 mm. below the isoelectric line. In Lead II twenty-five records showed a thickening and sloping into the RT segment 1.5 to 4 mm. above the base line, and four other records sloped into the ST segment 1.5 to 2 mm. below the isoelectric line. In Lead III sixty-three records had a high take-off of 1.5 to 7.5 mm. and six with a low take-off of 2 to 4 mm. The thickening and sloping of the R or S wave was not associated with a significantly elevated or depressed RT-ST segment although minor degrees of elevation or depression were frequently associated with the high or low take-off.

In most records the upstroke of the R wave was quick and sharp but in eight records with no Q wave the R wave was thickened and sloping from the PR interval for a height of 1 to 2 mm., and in one case, 6 mm.

Q-T Time.—The Q-T time was measured from the beginning of the QRS complex to the end of the T wave. Table XII shows the average duration in 500 records without reference to heart rate.

TABLE XII

Q-T TIME

LEAD	MEAN Q-T TIME	STANDARD DEVIATION OF MEAN	STANDARD ERROR OF MEAN	SIGNIF. LIMITS	HIGHLY SIGNIF. LIMITS
I	0.33	0.03	0.001	0.27 to 0.39	0.24 to 0.42
II	0.34	0.03	0.001	0.28 to 0.40	0.25 to 0.43
III	0.33	0.03	0.001	0.27 to 0.39	0.24 to 0.42

The above figures give some indication of the range of Q-T time but consideration must also be given to the relation of this interval to the heart rate. The Criteria Committee of the New York Heart Association[3] state that a correction for rate can be made by the formula $Q\text{-}T = K\sqrt{\text{cycle length}}$ and that the Q-T interval is regarded as prolonged if K exceeds 0.392 in men. Table XIII shows the mean K values and range of distribution in this group of 500.

TABLE XIII

CORRECTED Q-T TIME (K VALUE)

LEAD	MEAN K VALUE	STANDARD DEVIATION OF MEAN	STANDARD ERROR OF MEAN	SIGNIF. LIMITS (± 2 S.D.)	HIGHLY SIGNIF. (± 3 S.D.)
I	0.38	0.03	0.001	0.32 to 0.44	0.29 to 0.47
II	0.38	0.03	0.001	0.32 to 0.44	0.29 to 0.47
III	0.38	0.03	0.001	0.32 to 0.44	0.29 to 0.47

This table shows that the upper limits of the range of the corrected Q-T values are considerably higher than 0.392 in this group of young

men. In Lead I, 142 records, in Lead II, 197 records, and in Lead III, 158 records had a corrected Q-T time of 0.40 second or greater, while approximately 2 per cent of the records had a corrected Q-T time in excess of 0.44 second.

Axis Deviation.—Separate calculations were made of the axis deviation of each electrocardiogram on mimeographed duplicates of the Einthoven triangle illustrated by White.[12] Mathematical calculations on a large number of records showed that the margin of error by this method was less than 5 degrees.

Table XIV classifies the records according to the degree of axis deviation.

TABLE XIV

AXIS DEVIATION

RANGE OF AXIS DEVIATION (DEGREES)	NUMBER OF RECORDS
Less than 0	22
0 to 30	22
31 to 90	414
Over 90	42

By certain standards, only 22 records would be considered as left axis deviation, and, by others, 44 records. Forty-two showed right axis deviation. The mean axis deviation of the whole group was 65 degrees with a standard deviation of ±29 degrees and a standard error of ±1.3 degrees. The measurements of axis deviation were distributed essentially in a normal curve on either side of the mean with a slight scattering of some relatively large left axis deviation measurements.

The limits set by twice the standard deviation were 7 to 123 degrees, and only 5 per cent of the records fell outside this range. The limits set by three times the standard deviation were −22 degrees to 152 degrees. Only one record fell above the upper limit of this range, but 2 per cent of the records were less than −22 degrees. These electrocardiograms showed no significant characteristics other than the marked left axis deviation, and the men were all physically fit.

Extrasystoles.—Nine records of this group showed occasional ventricular extrasystoles and three had auricular extrasystoles. The recording of extrasystoles is largely a matter of chance depending upon their frequency and the length of the record. In the short records taken in this series, the above figures on incidence are quite without significance. There were no clinical findings of note in the men who had extrasystoles and no other consistent electrocardiographic peculiarities.

DISCUSSION

Although the human electrocardiogram is relatively constant, it shows considerable variation with respect to the number of deflections and their amplitude and time relations. Certain of these characteristics of the

electrocardiogram have been definitely correlated with cardiac abnormalities. Others are said to occur more frequently in abnormal than in normal hearts, but cannot alone be considered of diagnostic significance in a cardiac examination. The present group of 500 electrocardiograms, which was closely comparable to a previous group of 2,000, show the range of variation in healthy young aircrew trainees. Of this group of physically fit young men, 18 per cent had peculiarities in their electrocardiographic records, which placed them in the doubtful or definitely abnormal categories according to present standards. An additional number of records showed less important variations from the defined normal, such as, extremes of wave amplitude, negative P waves, extrasystoles, etc. When 15 to 20 per cent of normal healthy young men have electrocardiograms which fall in the abnormal class, the definitions of electrocardiographic abnormality require revision, or a careful study is needed to determine whether these same men may later develop cardiac disease. Since the number of apparently abnormal electrocardiograms is so great in young men showing no clinical evidence of cardiac abnormality, and since we have insufficient experience by which to judge the significance of various types of electrocardiographic abnormality in flying personnel, the present system of selection, in which the electrocardiogram is used only as confirmatory evidence in cases showing doubtful clinical evidence of heart disease, seems well justified. A definitely abnormal electrocardiogram alone is not considered sufficient to exclude a man from a flying category if he is fit clinically. However, further experience may show the desirability of taking the electrocardiographic abnormality alone as cause for rejection in certain cases. Since 18 per cent of these men showed definite, if not diagnostic, abnormalities according to present standards, at least an equal number of the men who later claim pension for cardiac disabilities might be expected to show similar findings, and an earlier record will be of great aid in evaluating the significance of the electrocardiographic findings. Routine enlistment electrocardiograms would also be of assistance in confirming the diagnosis when electrocardiographic changes had developed during the period of service.

The limits of amplitude set by twice the standard deviation above and below the mean, corresponded closely with previously accepted standards in the case of the P wave, the upper limits being 1.3, 2.5, and 1.9 mm., in Leads I, II, and III, respectively. However, 3 to 4 per cent of the group showed amplitudes above these limits, with 3 mm. as the maximum limit in Lead II. Consistently negative or diphasic P waves occurred slightly less frequently in Leads I and II of this series than in the group of 2,000 aircrew previously studied, where they were noted in approximately 1 per cent of the records. Three additional records showed occasional negative P waves in auricular extrasystolic complexes. All these negative P waves occurred in the records of perfectly normal men and probably cannot be considered of any sig-

nificance from a clinical standpoint. Negative and diphasic P waves occurred in Lead III in 18 per cent of electrocardiographic records both in this group and in the previous 2,000. This was a considerably larger number than the 3 to 5 per cent reported by Ashman and Hull.[1] Notching of the P waves occurred with such frequency in normal records that it is probably of little significance.

The limits of P-R duration as set by twice the standard deviation above and below the mean were 0.11 to 0.21 second in Lead II. The duration was slightly longer in Lead II than in the other leads. Five per cent of this group of young men had electrocardiograms with P-R intervals beyond this range, half of them showing a prolonged P-R interval by present standards and half a short P-R interval. It cannot be stated positively, of course, that those men with a P-R interval beyond 0.20 second were absolutely normal, or that they will not later show clinical evidence of cardiac disease. However, it can be said that careful clinical and radiological examinations on repeated occasions have shown no significant abnormalities, and that all of the men had cardiac function efficient enough to permit strenuous physical effort in drill and sports. This is equally true of the few men who had P-R over 0.24 second, as of those between 0.21 and 0.24 second, but one must look with somewhat more suspicion on a record with a P-R greater than 0.24 second since they are likely to occur only about three times in a thousand normal individuals.

The significance of a deep Q wave in the absence of other electrocardiographic abnormalities is not clear. Pardee and Price[11] list it as one of the abnormal characteristics of the ventricular complex which, they show, are related in a large percentage of cases to pathologic changes of the myocardium or to the anginal syndrome.[10] Two to 3 per cent of the group of five hundred showed deep Q waves according to present standards with no clinical or other evidence of cardiac disfunction. A follow-up of these cases may prove of interest.

The limits of R-wave amplitude in this group correspond closely to present standards. A range of 6 to 22 mm. includes 95 per cent of the group, and 2 to 26 mm. constitutes the extreme limits with only occasional measurements extending beyond this range in normal young men.

The frequency distribution of the Q and S waves differs considerably from the normal curves evidenced by other complexes and time intervals. Both appear like half of a normal curve with maximum incidence at zero. The greatest amplitude of the Q wave was approximately 4 mm., and that of the S wave, 9 mm.

Slurring or notching of the QRS complex occurred with such frequency in Lead III (26 per cent) in these records that it cannot be considered of much significance. It also occurs in approximately 3

per cent of records in Leads I and II without any definite correlation with other electrocardiographic abnormalities, although a few cases occurred with a borderline or slightly widened QRS interval. It is stated that records with a splintering or slurring in two leads, one nearer the apex than the other, is indicative of an abnormality. Some of these records showed this characteristic, but the percentage of the total group was small.

Fewer negative or diphasic T waves were noted in Leads I and II of this series of 500, than in the 2,000 men previously studied. However, an examination of this characteristic in a further group of 2,000 records taken after the present 500 again showed that 0.5 to 1 per cent of the records had negative or diphasic T waves in Leads I and II. A number of these records are discussed in a later report.[8]

As in the case of the apparently prolonged P-R intervals, it cannot be stated with certainty that the individuals showing negative or diphasic T_1 or T_2 have normal hearts, but there was no clinically determined abnormality in any of them and they made an excellent physical response to effort at the time these records were taken. Electrocardiograms of this type were found in the youngest men of the group as well as among those over 25 years.

The likelihood of coronary occlusion occurring in young men below 25 years of age is debated, and the significance of electrocardiographic characteristics usually considered typical of impaired or decreased coronary blood flow is also in doubt. One airman, not in this series,[8] had negative T waves in Leads I and II, and later died, after a period of active flying service overseas, of what was diagnosed as "acute heart failure." Others who showed this electrocardiographic characteristic are being carefully followed up to determine whether the incidence of coronary lesions may be higher than in other groups.[8] It is probable that, even in young men of apparently excellent health and physical condition, persistently negative T waves in Leads I or II may be sufficient evidence of disturbed cardiac function to justify elimination from aircrew training. There were no consistent changes in the RT-ST segment in the records showing negative T waves, but, as has been mentioned, a small number of other records showed an elevation or depression slightly greater than the standard limit of 1 mm. It may be that this limit should be increased to 1.5 mm. before being considered significant, but the men who had electrocardiographic records with an RT-ST segment above or below the 1 mm. limit are being followed up to determine whether any clinical evidence of cardiac disease may develop. The range of amplitude of T_2 was 1 to 6.6 mm. as set by twice the standard deviation, and 0 to 8 mm. as set by three times the standard deviation from the mean. This suggests that the usually accepted standard of 6 mm. as an abnormally high amplitude might be revised upward to 8 mm. since 3.8 per cent of these normal young men had T-wave amplitudes in excess of 6 mm.

In this group, the average duration of the electrical impulse resulting from ventricular systole was 0.38 second as measured by the Q-T time corrected for variations in cardiac rate. The range of the corrected Q-T period extended to 0.44 second, and almost 40 per cent of the records exceeded the standard of 0.392 second, which is at present accepted as the upper limit of normal.

A relatively large number of records showed right or left axis deviation, 17.2 per cent according to the standards of the Criteria Committee of the New York Heart Association,[3] which set 30 to 90 degrees as the limits of the normal range. According to White[12] the normal limits are 0 to 90 degrees, and by this method a right axis deviation is present if S_1 exceeds R_1. However, left axis deviation is present only if S_3 exceeds R_3 to a more marked extent and R_1 minus S_1 is also relatively large. When the methods defined by the Criteria Committee are used, both right and left axis deviation seem to be measured by the same standards since an S_3 even slightly greater than R_3 then places a record in the left axis deviation group. It would appear, however, from the present analysis, that the normal range should be widened in the direction of the right axis deviation rather than narrowed from the left axis side to 30 degrees. A range of 0 to 120 degrees would include all but 5 per cent of normals, and the limits of −25 to +150 degrees would be necessary to include all but 0.3 per cent of the normals.

This does not mean that all measurements of the deviation of electrical axis within these ranges will be normal, but that the observer who states that they are abnormal without additional proof will have to accept the responsibility for at least a 5 per cent chance of error if the measurement is beyond the 0 to 120 degree range, and up to a 20 per cent chance of error if he accepts the 30 to 90 degree range. Of course, he may be perfectly willing to do this. Any observer can select his own standard of accuracy. However, when the limits are as narrow as those referred to above, i.e., White 0 to 90 degrees, Criteria Committee of the New York Heart Association 30 to 90 degrees, and Ashman and Hull 40 to 90 degrees, the observer must realize that he will be wrong in his decision as to normality or abnormality in 15 to 25 per cent of the cases. As has already been pointed out, the group of men showing left or right axis deviation was clinically normal in all respects in so far as could be determined.

There are two definite types of so-called axis deviation, an apparent deviation in which the position of the heart is changed in its relation to the hypothetical triangle representing the three electrocardiographic leads. Changes can be made to occur in axis deviation by posture or respiration, rotating or moving the heart with relation to this triangle. In some cases, too, the heart may be fixed in the chest so as to give the same effect as a change produced by deep inspiration, as in a tall, narrow-chested person. This type of electrocardiogram cannot be

considered as abnormal even if the axis deviation goes well beyond the accepted normal limits. The second type of axis deviation is definitely abnormal. In this the alteration of wave complexes is produced by a definite right or left ventricular hypertrophy or by bundle branch block in which the electrical waves of the two ventricles are not superimposed in the normal manner. In the former, additional evidence of the abnormality will probably be shown radiologically or clinically, and in the latter the electrocardiogram will in most cases also show a definite conduction defect. Borderline cases, of course, will exist in both groups. In the present series of 500 there were no cases which fell into the second grouping. All were proven normal clinically and radiologically. Although we have no definite evidence of the relationship of these axis deviations to position of the heart, we must assume that the apparent deviations were due to what may be called anatomic variations rather than pathologic ones. As is shown in a later report, some of these records with axis deviation could be changed to normal by a change in posture.

SUMMARY AND CONCLUSIONS

A statistical analysis is presented of the complexes of 500 electrocardiograms taken on Royal Canadian Air Force aircrew. The direction and mean amplitude of the complexes, the standard deviation from the mean and the limits of the distribution as set by two or three times the standard deviation is reported for healthy young adult males between the ages of 18 and 32 years.

P Wave.—The upper limits for the P wave, set by twice the standard deviation, were found to be 1.3, 2.5, and 1.9 mm., in Leads I, II, and III, respectively. Three to 4 per cent of the group showed amplitudes above these limits, with 3 mm. as the maximum limit in Lead II. Although the majority of P waves formed a rounded summit, a considerable number showed a sharp or pointed P wave, and over 5 per cent were notched in varying degrees at the apex.

P-R Interval.—The limits of P-R duration as set by twice the standard deviation were 0.11 to 0.21 second in Lead II, the duration being slightly longer in Lead II than in the other leads. In this group, 5 per cent of the electrocardiograms had P-R intervals beyond this range; 2½ per cent were less than 0.11 second and 2½ per cent greater than 0.21 second in duration.

QRS Complex.—Slurring or notching of the QRS complex occurred in approximately 3 per cent of the records in Leads I and II, and a few of these occurred with a borderline or slightly widened QRS interval. In Lead III this occurred much more frequently and was noted in 26 per cent of the records.

In Lead I, a Q wave was present in 29 per cent of the records, in Lead II in 58 per cent of the records, and in Lead III in 61 per cent of the records. Two to 3 per cent of the 500 records showed deep Q

waves according to present standards. In these cases there were no other significant electrocardiographic abnormalities and the men were clinically normal in all respects. The greatest Q-wave amplitude was 6 mm.

The limits for the R-wave amplitude set by twice the standard deviation were 1.2 to 12 mm. in Lead I, with 3.8 per cent beyond this range; 6.1 to 22 mm. in Lead II, with 5 per cent beyond this range, and 0 to 18.7 mm. in Lead III, with 1.2 per cent beyond this range. The limits of R-wave amplitude in this group correspond closely to present standards. A range of 6 to 22 mm. included 95 per cent of the records.

In approximately 75 per cent of the records, an S wave was present with a mean amplitude of 2.5 mm. The Q and S waves did not show a normal curve of distribution; consequently, standard deviation from the mean was not calculated. The majority of S waves were 1 to 3 mm. in amplitude, with a maximum of 9 to 10 mm. in three records.

The upper limit of QRS time, in this series, set by twice the standard deviation, corresponds with the usually accepted limit of 0.10 second. In Lead I the QRS intervals did not exceed this limit, in Lead II five records had QRS intervals in excess of 0.10 second, and in Lead III six records.

Axis Deviation.—The limits of range for axis deviation set by twice the standard deviation were 7 to 123 degrees, and only 5 per cent of the records fell outside this range.

T Wave.—The limits for T-wave amplitude set by twice the standard deviation were 1 to 5 mm. in Lead I, with 3.4 per cent beyond this range; 1 to 6.6 mm. in Lead II with 3.8 per cent beyond this range, and −1.4 to 3.4 in Lead III, with 4.2 per cent beyond this range. The curve of distribution was normal with less than 5 per cent T waves outside the limits of twice the standard deviation. Twenty-eight per cent of the records showed diphasic or negative T waves in Lead III but only one record had diphasic T waves in Lead II.

RT-ST Segment.—Elevation of the RT segment greater than 1 mm. occurred in Lead I in one record, and in Lead II in five records, but in Lead III there were no records with an elevation greater than 1 mm. Depression of the segment greater than 1 mm. was noted in Lead III only, in three records.

In Lead I slight elevation of segment (77 records) were much more common than depressions (two records, 0.5 mm.), whereas in Lead III depression (0.79 mm.) was more frequent (79 records) than elevation (24 records, 0.6 mm.).

CONCLUSIONS

In general, it may be stated that the range of variation in the electrocardiograms of normal young airmen is considerably greater than the present standards would lead one to expect, and a relatively large

number of records show characteristics which hitherto have been considered diagnostic of heart disease.

Further follow-up studies are required to evaluate the significance of these findings over a period of years. At present, there is no evidence that a healthy young man should not be permitted to continue flying even if he shows what is now considered to be a definite electrocardiographic abnormality, although a follow-up study now being made may show that certain electrocardiographic findings alone should be considered as cause for rejection from aircrew. It would seem, however, that the value of routine electrocardiograms of service personnel may be more valuable for comparative purposes in future pension cases than in primary selection, although they are of definite confirmatory value in the enlistment examination of a number of men with doubtful clinical findings of a cardiac nature.

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ANALYSIS OF THE ELECTROCARDIOGRAMS OBTAINED FROM 1000 YOUNG HEALTHY AVIATORS

COMDR. ASHTON GRAYBIEL, M.C.-V(S), U.S.N.R.,
ROSS A. MCFARLAND, PH.D.,
LT. COMDR. DONALD C. GATES, M.C., U.S.N.R., AND
LT. FRED A. WEBSTER, H-V(S), U.S.N.R.

DURING the course of some investigations[1] on a group of Civil Air Line pilots, the electrocardiographic findings proved to be of more than passing interest because of the relatively large number of deviations from the values generally regarded as being normal. Because of their relatively frequent occurrence in the records from apparently healthy persons, it was not easy to believe that all of these deviations declared some underlying cardiac abnormality. The opportunity to extend this study came a year later when electrocardiograms were obtained from a large number of young aviators at the Naval Air Station, Pensacola, Florida. Although the primary purpose of this study is to add to our knowledge of the range of the normal electrocardiogram, some attention is also given to an appraisal of the usefulness of electrocardiography in aviation medicine.

SUBJECTS AND PROCEDURE

All of the 1,000 subjects were males. Eighty-five were advanced student aviators in one of the government sponsored training programs; all the rest were Naval Aviators or Student Naval Aviators. They ranged from 20 to 30 years of age, with a mean of 23.7 years. Approximately 77 per cent were within 10 per cent of the Navy standard of height-weight relationship; 18.4 per cent were overweight, and 4.3 per cent underweight. They were originally selected for flight training only after meeting the most exacting physical requirements, and, in addition, each subject received a careful physical examination at the time our studies were made. All were in good health and none had any signs or symptoms of heart disease.

All of the electrocardiograms were obtained with the subject in the recumbent position and, with a small number of exceptions, in the basal state. Leads IV F and IV R were obtained in addition to the

From the U. S. Naval School of Aviation Medicine, Pensacola, Florida, and the Division of Research, Graduate School of Business Administration, Harvard University.

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The views and opinions expressed in this paper are those of the authors and are not necessarily the views of the organizations mentioned above.

standard three leads. The electrodes and lead wires were so adjusted that after recording Lead IV F, Lead IV R could be obtained by simply turning the lead-selector switch; thus, the conditions were identical during the recording of both precordial leads.

Sanborn electrocardiographs (cardiettes) were used throughout the study. The timing device was repeatedly checked for accuracy, and all of the instruments were returned to the factory for overhaul at least once during the study. More than ordinary care was taken in the procuring and developing of the records.

The various measurements obtained from the electrocardiograms were carefully made. A magnifying lens was used in determining the duration of the QRS complex and sometimes in measuring the amplitude or duration of other deflections. The data obtained were all recorded on master sheets and the statistical analysis made from these figures.

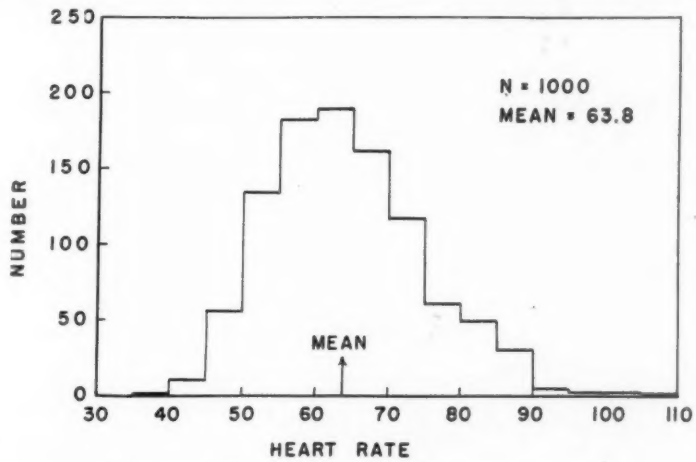

Fig. 1.—Range and distribution of heart rates.

THE HEART RATE

The heart rate was determined from the electrocardiogram by taking the average of three or four measurements of 6 seconds each. The range was from 38 to 110. The mean heart rate was 63.8 and the mode 62. The histogram in Fig. 1 shows the distribution, and it is noteworthy that in only three instances was the heart rate above 100. The mean heart rate of the subjects in this series is nearly the same as that found by Robinson[2] and by Brouha and Heath[3] in their groups of young subjects who were examined in the basal state, and by McFarland, et al.,[1] in a group of civilian pilots.

RHYTHM

Normal Rhythm.—In the study of the electrocardiogram, normal rhythm is defined as a nearly regular sequence of beats between the

rates of 60 and 100* in which the excitation impulse arises normally in the S-A node and is conducted normally throughout the heart. All other rates and rhythms have a special name and are often grouped under the "disorders or disturbances of rhythm."

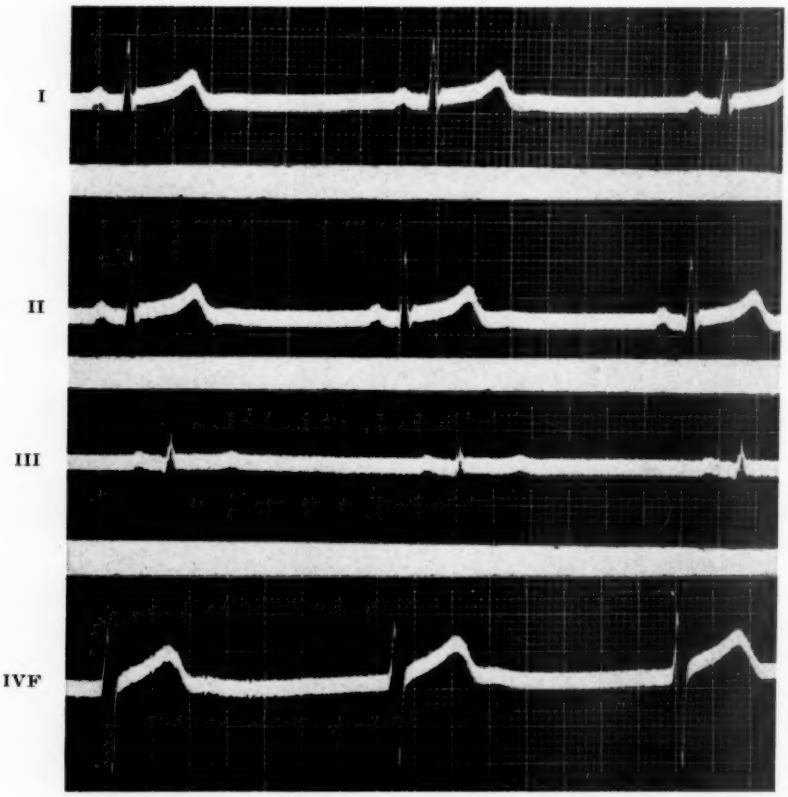

Fig. 2.—S-A bradycardia (rate 38).

Sinus Bradycardia.—Heart rates between 50 and 60 were very common and almost a third (315) of our subjects had rates within this range, and more than one-third (382) had rates below 60. It is perhaps unfortunate that such narrow limits have been set with regard to heart rate in defining normal rhythm. The term sinus bradycardia might more properly be reserved for rates below 45. The extreme S-A bradycardia (rate 38) observed in one case (Fig. 2) is of interest because it is one of the few examples on record[4] of a heart rate slower than 40 beats a minute in a healthy well-nourished person.

Sinoauricular Tachycardia.—Three of our subjects had heart rates between 100 and 110. While it has been shown[3] that young, healthy, well-trained athletes at rest have pulse rates above 100, tachycardia of this degree should be regarded with suspicion.

*This is the range adopted by the American Heart Association.

Sinus Arrhythmia.—No especial attention was given to this arrhythmia, but in 56 instances it was sufficiently pronounced for a notation of its presence to be made.

Variations in the Location of the Pacemaker.—There were 23 instances of *wandering of the pacemaker* in and about the S-A node. These were all characterized by variations in the form of the P waves and with the P-R interval remaining unchanged. This unimportant form of arrhythmia has no pathologic significance. A single instance was observed of *S-A block with A-V nodal escape.* This too has no pathologic connotation. There was one example of A-V nodal rhythm with short P-R interval (0.09 second) and inversion of the P waves in Leads II and III. The rhythm was regular at a rate of 77 a minute. Although nodal rhythm may result from heart disease, it is usually to be regarded as a disturbance of rhythm which neither causes symptoms nor is associated with diseases of the heart. The above instance is unusual in that the rate is relatively rapid, which indicates a heightened irritability of the A-V node more than depression of the S-A node.

Short P-R Interval and Wide QRS Waves.—There were two examples (Figs. 3 and 4) of this curious arrhythmia, first described by Wolff, Parkinson, and White.[5] Recent studies[6] have shown that it may be the result of an anamolous connection between the auricles and ventricles. Because persons with this anomaly are prone to have attacks of paroxysmal tachycardia, its presence should disqualify a candidate for flight training. The discovery of two cases in 1,000 may not represent its true incidence but does suggest that it occurs sufficiently often that it must not be neglected.

Premature Beats.—The electrocardiograms in fifteen instances showed premature beats; eight were of the ventricular and seven of the auricular variety. The actual incidence of premature beats in our subjects was probably many times greater than we observed, as the recording time was short. Although the number of cases observed is too small to be of statistical significance, yet it is of a little interest that in this young, healthy group there were nearly the same number of auricular as ventricular premature beats. The latter are ordinarily regarded as occurring three or four times as frequently as the former.

Heart Block.—There were sixteen instances of the so-called first stage of heart block or prolongation of the A-V conduction time beyond 0.20 second. This will be discussed below under P-R Interval.

Intraventricular Conduction Defects.—There were 38 electrocardiograms in which the duration of QRS was more than 0.10 second. These will be discussed under QRS Complex below.

THE P WAVES

The duration, amplitude, and form of the P waves were determined in the three standard leads. The duration of P was measured from the point on the lower edge of the base line at which it left the

zero level to the point of return. The amplitude was measured from the upper or lower edge of the base line to the peak, respectively, according to whether P was upright or inverted. The forms of the P wave were classed as follows: pointed, rounded, notched, and diphasic.

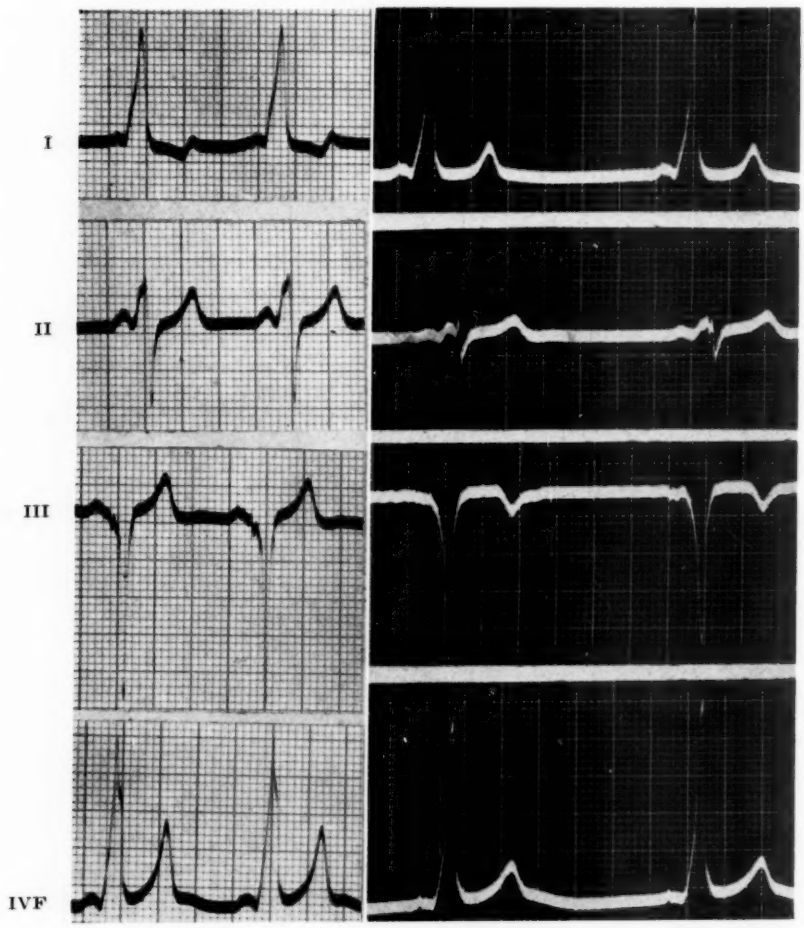

Fig. 3.—Short P-R and wide QRS. Fig. 4.—Short P-R and wide QRS.

Duration of P.—The values for the entire range of the duration of P are shown in Table I. Particular interest centers in the extremes. P waves were always observed in Lead II and were absent in only one instance in Lead I and one in Lead III. When the P waves in one or other of the three leads were tiny, the duration was correspondingly short. P waves of more than 0.1 second duration were observed only occasionally.

Amplitude of P.—Table II shows the range of the amplitude of P except in three instances of abnormal rhythm. In Lead I, P was seldom

TABLE I

DURATION OF THE P WAVE IN THE STANDARD LEADS

DURATION OF P (SEC.)	PERCENTAGE		
	LEAD I	LEAD II	LEAD III
0.00	0.1	-	0.1
0.01	-	-	0.1
0.02	0.3	0.1	0.4
0.03	0.7	0.2	0.6
0.04	6.9	1.0	6.3
0.05	4.5	0.4	5.6
0.06	18.5	4.3	22.4
0.07	11.5	6.3	15.1
0.08	37.5	35.3	35.2
0.09	9.3	25.8	8.4
0.10	9.4	22.2	4.4
0.11	1.0	2.9	0.9
0.12	0.3	1.5	0.5
Mean Duration	0.074	0.086	0.073

TABLE II

AMPLITUDE OF THE P WAVE IN THE STANDARD LEADS

AMPLITUDE OF P (MM.)	PERCENTAGE		
	LEAD I	LEAD II	LEAD III
-0.9 to -2.0	-	-	0.4
-0.5 to -0.8	-	0.1	3.8
-0.1 to -0.4	-	-	2.7
0	-	-	0.1
0.0 to +0.3	13.4	2.3	8.0
+0.4 to +0.7	57.9	16.4	29.2
+0.8 to +1.1	26.8	38.1	29.2
+1.2 to +1.5	1.4	33.9	8.8
+1.6 to +1.9	-	4.9	0.6
+2.0 to +2.3	-	1.6	0.4
+2.4 to +2.7	-	0.4	0.1
+2.8 to +3.0	-	0.1	-
Diphasic (+-)	0.5	1.3	14.1
Diphasic (-+)	-	0.9	2.5

more than 1 mm. in amplitude and was never actually inverted; in five instances P was diphasic. In Lead II, P was seldom greater than 2 mm. in amplitude, was occasionally diphasic, and actually inverted in only one instance. In Lead III, P was seldom more than 1.5 mm. in amplitude, was often diphasic and sometimes inverted. It is noteworthy that when P was diphasic, the upright preceded the downward phase in all but three instances.

Form of P.—Table III shows the various forms of P observed in the three standard leads. The distinction between rounded and pointed was made arbitrarily on the basis of whether the summit of P was part of a curve, or a peak. All degrees of notching are included under "notched," which accounts for the large frequency of notched waves. However, it again serves to emphasize the fact that notching is very commonly found. Diphasic P waves were rarely found in Leads I and II but were commonly found in Lead III.

TABLE III

FORM OF THE P WAVES IN THE STANDARD LEADS

FORM OF P	PERCENTAGE		
	LEAD I	LEAD II	LEAD III
Apex rounded	49.8	29.4	28.4
Apex pointed	22.3	41.1	25.8
Notched	27.5	28.2	26.3
Diphasic	0.5	1.6	16.1

P-R INTERVAL

The P-R or P-Q interval was determined by measuring from the beginning of the P wave to the beginning of the QRS complex. This measurement was made in Lead II except in occasional instances where the P waves were poorly defined or where P-R was of longer duration in another lead. The P-R interval was found to vary in duration from 0.09 to 0.28 second, and the mean was 0.154. In all but 82 instances the P-R varied between 0.12 and 0.18 second as shown in Table IV. This requires no further comment because these values are well within the generally accepted range for healthy young adults.

The P-R interval was 0.11 second in six instances, and 0.10 in seven others; in two of the latter (Figs. 3 and 4), the QRS complexes were abnormally wide as described above. The P-R interval was 0.09 second in the one instance of A-V nodal rhythm. An example of short P-R with normal QRS is shown in Fig. 5. The impulse passes with unusual rapidity from auricles to ventricles, and there is, presumably, less delay than ordinarily in the junctional tissue surrounding the A-V node.

TABLE IV

DURATION OF THE P-R INTERVAL

P-R INTERVAL (SEC.)	NUMBER OF INSTANCES
0.12	76
0.13	83
0.14	211
0.15	117
0.16	249
0.17	95
0.18	84
	Total = 915

The P-R interval was 0.19 second in 19 instances and 0.20 in 33 instances. Although these values are within the usually accepted normal range, it is worth remarking that these values occurred infrequently. Of greater significance was the finding of P-R intervals of 0.21 second in four instances, 0.22 second in eight instances, and one instance each where the P-R interval was 0.24, 0.25, 0.26, and 0.28 second. There was no evidence of rheumatic fever in any of these cases, and careful examination did not disclose any infection or other abnormality. Unfortunately, we were not able to observe these cases for longer than a few days. Other investigators, likewise, have occasionally

observed abnormally long P-R intervals in otherwise healthy persons. Thus, Ferguson and O'Connell[7] found the P-R interval to be longer than 0.20 second in over 1 per cent of the electrocardiograms from 1,812 healthy young men. Hall, Stewart, and Manning[8] likewise observed the P-R interval to be over 0.20 second in nearly 2 per cent of the electrocardiograms from 2,000 apparently healthy persons. Thus, although P-R intervals greater than 0.20 second should raise the question of past or present heart disease, they may indicate neither.

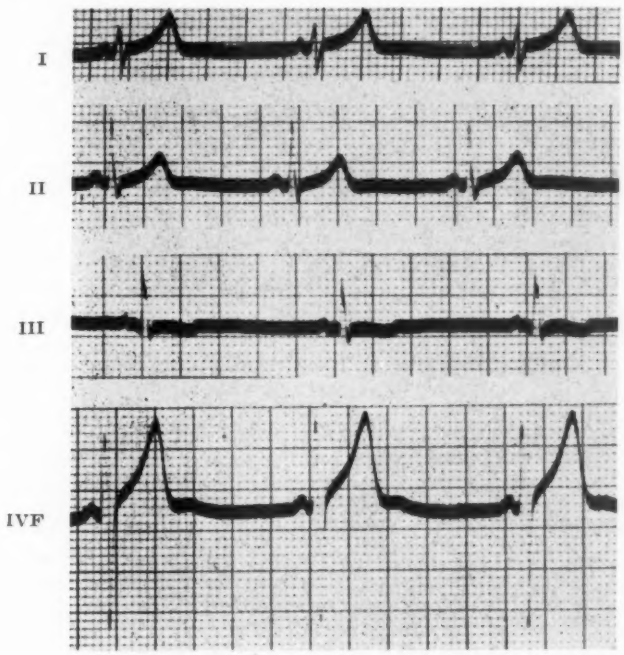

Fig. 5.—Short P-R and normal QRS.

The P-R interval is known to vary with the length of the cardiac cycle or heart rate; this relationship is shown in Table V. P-R intervals longer than 0.20 second were not found at heart rates of 80 or above.

QRS COMPLEX

Before proceeding to the description of the QRS findings, it is necessary to mention the terminology used and the manner in which the several waves were measured. The present study was begun prior to the appearance of a report on electrocardiographic terminology made by the Committee for the American Heart Association,[9] but the terminology used here does not vary very much from that recommended. A single upstroke is called R, any preceding downstroke Q, and any following downstroke S. All other forms are separately described as follows: in the absence of Q as defined above, a heavy slurring at the base line on the upstroke of R is termed a "fused Q wave." If a tiny upstroke

TABLE V

VARIATION IN THE P-R INTERVAL WITH HEART RATE

RATE	NUMBER	P-R INTERVAL CORRELATED WITH HEART RATE	
		MEAN (SEC.)	RANGE (SEC.)
40-49	60	0.159	0.12-0.20
50-59	315	0.157	0.10-0.28
60-69	349	0.153	0.10-0.25
70-79	174	0.152	0.11-0.24
80-89	76	0.144	0.09-0.20
90-99	13	0.145	0.12-0.18

TABLE VI

DURATION OF QRS

DURATION OF QRS (SEC.)	NUMBER OF INSTANCES
0.06	7
0.07	68
0.08	431
0.09	295
0.10	161
0.11	27
0.12	8
0.13	1
0.14	2
	Total = 1,000

precedes Q, it is considered part of that wave and described separately. The same terminology applies to S. A QRS complex of low amplitude consisting of several waves is termed a "vibratory QRS complex."

The duration of QRS was measured in the lead giving this wave the greatest value. The amplitude of Q and S were determined by measuring from the level of the lower margin of the P-Q segment to the apex of the wave, and the level of the upper margin was used in the case of R. Notching refers to a definite spike, and slurring to a definite thickening, more than 2 mm. from the base line on one of the limbs of Q, R, or S which has an amplitude of 5 mm. or more.

Duration of QRS.—The duration of QRS was found to vary from 0.06 to 0.14 second with a mean value of 0.087; Table VI gives the figures for the entire range. It is of interest to compare these findings with those of other investigators.

The duration of QRS was measured by McGinn and White[10] with the aid of a Lucas comparator and was found to average 0.0833 second in 50 adult males of all ages, and 0.0722 in 50 females. Earlier studies reported similar average values but were based on smaller series of cases. Shipley and Halloran[11] obtained average values of 0.087 second for males and 0.085 second for females in a series of 200 cases. Lüderitz[12] found the average duration of QRS to be 0.080 second in 500 cases. The values obtained by Haskin and Jonescu[13] were extraordinarily small, due to the manner in which they measured the QRS duration.

The *range* of the QRS duration is of far greater importance than the *average* value because at the upper extreme there is considerable overlap with the abnormal. Practically all of the early electrocardiographers, beginning with Lewis,[6] considered 0.10 second as the upper normal limit. Here again, the conclusion was based on the study of a small series of cases. Ferguson and O'Connell[7] reported finding the QRS longer than 0.10 second in two tracings from 1,812 healthy young men. McGinn and White[10] observed three instances in 100 where the duration of QRS was between 0.10 and 0.11 second. Shipley and Halloran[11] observed the duration of QRS to be 0.11 second in two instances and 0.12 in one, in their series of 200 cases. Lüderitz[12] discovered the QRS duration to be 0.11 second in nine and 0.12 in two instances among 500. Chamberlain and Hay[14] did not observe any QRS waves longer than 0.10 second, but their observations in this regard were limited to Lead II, whereas the duration of QRS is often greater in Lead III or even in Lead I. Haskin and Jonescu,[13] in a study of 50 normal women, found the longest duration of QRS to be 0.09 second. Ashman and Hull,[15] in their series of 100 cases, did not find any QRS waves longer than 0.10 second, and Hall, Stewart, and Manning,[8] in an analysis of 2,000 records, found only two showing QRS waves greater than 0.10 second. It is readily seen from these reports that QRS waves in the standard leads greater than 0.10 second in duration are rarely encountered in the electrocardiograms from healthy persons. Inasmuch as a diagnosis of "normal" heart cannot be made with finality in the living, and the fact that there are occasional cases showing a considerable degree of coronary arteriosclerosis at an early age, the evaluation of these unusual records is difficult. Because of the interest in, and importance of, this problem, it seems worth while to discuss in more detail the cases in our series where QRS was found to be greater than 0.10 second in duration.

In 27 instances (2.7 per cent) QRS measured 0.11 second. In every case it was found that this measurement was obtained in a lead plainly showing Q, R, and S. In other words, it was unlikely that any portion of this complex was isoelectric and "buried" in the base line. In most of the 27 instances a casual glance at the record might not immediately raise the suspicion that QRS was unusually long; the form of the ventricular components did not appear abnormal. It was only after careful measurement that the QRS was discovered to be prolonged. It is our opinion that if the full duration of QRS can be observed, and if it is carefully measured, durations longer than 0.10 second will occasionally be found in the records from healthy males. Thinking in terms of the laws of probability, it seems unlikely that 27 subjects in our series had heart disease interfering with the conduction of the excitation wave through the ventricles.

There were eight instances in which the duration of QRS was 0.12 second. In seven of these eight, the form of the S-T segments and T waves was normal, and the only unusual feature was the extraordinary length of QRS. Examples of this are shown in Figs. 6 and 7. The remaining instance (Fig. 8) shows typical left bundle branch block with the T waves oppositely directed to the chief initial ventricular deflection in Leads I and III. This record was obtained from a Naval Aviator, aged 29 years. He was studied and tested in the most thorough manner but no evidence of heart disease was discovered. His progress was followed for two years (until the onset of the War) and he remained in good health. The cause of the conduction defect in this case is not known but it is not unreasonable to suppose that, rarely, even in young, apparently healthy persons, congenital anomalies of the conduction system, or injury from localized inflammation, or disease of the nutritive artery, may be responsible.

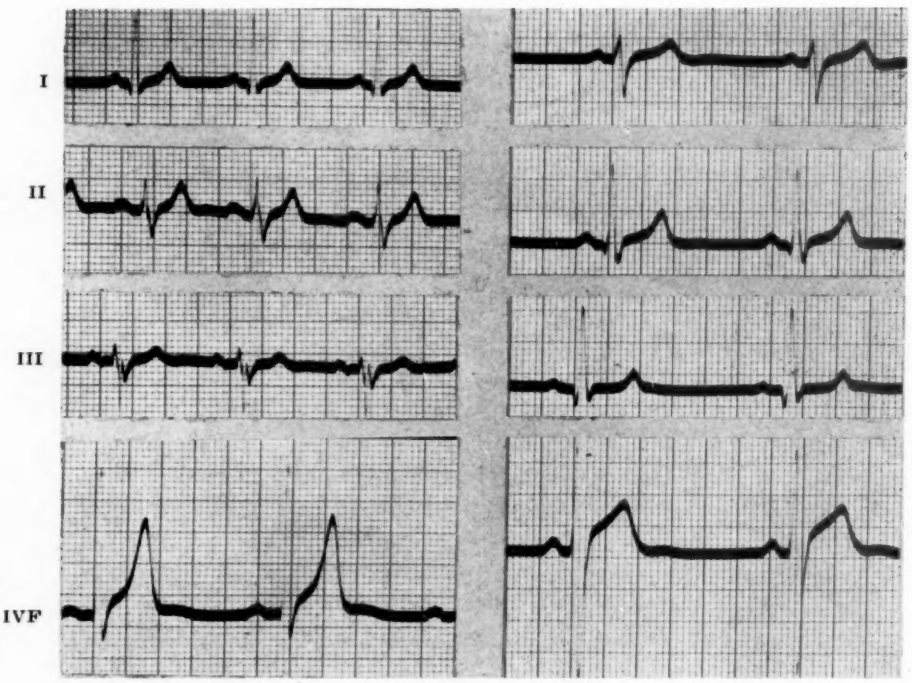

Fig. 6.—QRS = 0.12 second.

Fig. 7.—QRS = 0.12 second.

Another interesting example is seen in Figs. 9 and 10. These tracings were obtained from a student Naval Aviator, 24 years of age. The record in Fig. 9 was taken with the subject under basal conditions and the record in Fig. 10 was taken a few minutes later after a pistol had been fired near him. The change in intraventricular conduction occurred within 30 seconds of the explosion, and the abnormality remained for

two days. This subject was studied exhaustively but no evidence of heart disease or impairment was found. The fact that the faulty conduction occurred as a temporary functional condition is significant. It indicates the possibility that all disturbances of intraventricular conduction need not be explained on an anatomic basis.

There was one instance where the duration of QRS was found to be 0.13 second; the S-T segments and T waves were not affected. Thorough study and testing did not reveal any evidence of cardiac disorder.

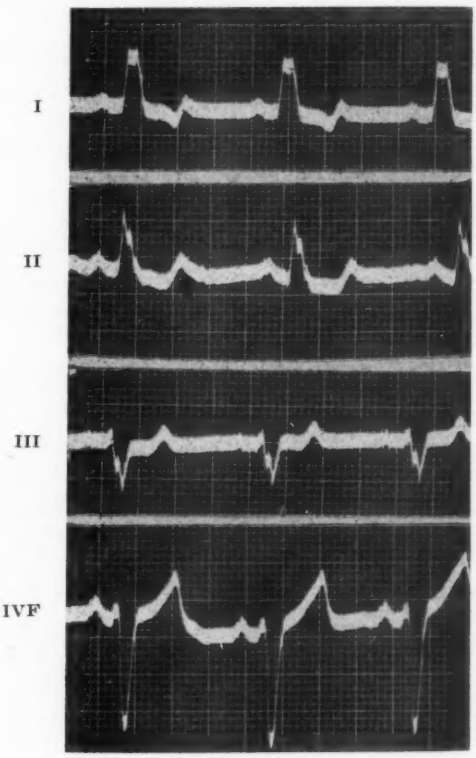

Fig. 8.—Left bundle branch block.

And, lastly, there were two instances of wide QRS associated with a short P-R interval. This phenomenon and its significance have been discussed above.

While freely admitting the uncertainties with regard to the unusual prolongations of QRS observed in this series, the following conclusions seem to be justified.

1. QRS complexes as long in duration as 0.13 second may be observed in young persons without any evidence of heart disease.

2. A QRS duration of 0.11 second is found with sufficient frequency in young healthy persons to suggest that it is not necessarily of pathologic significance.

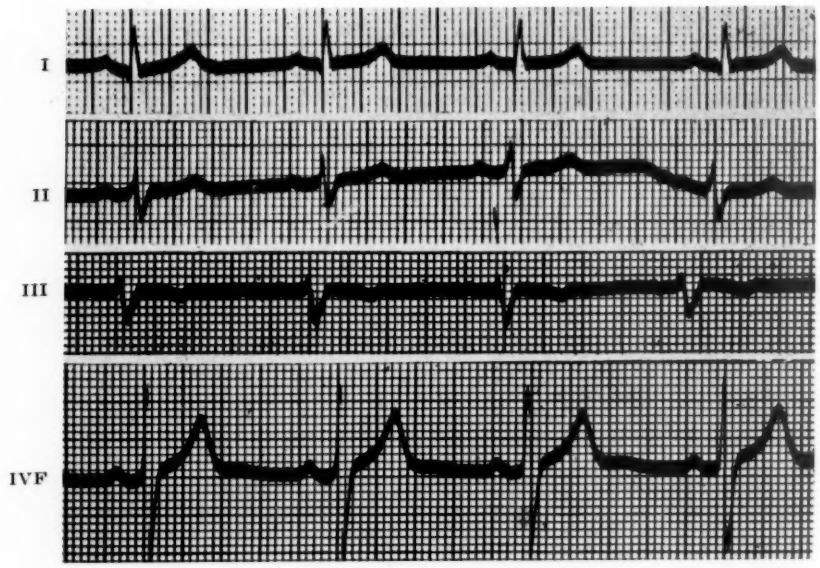

Fig. 9.—Control record.

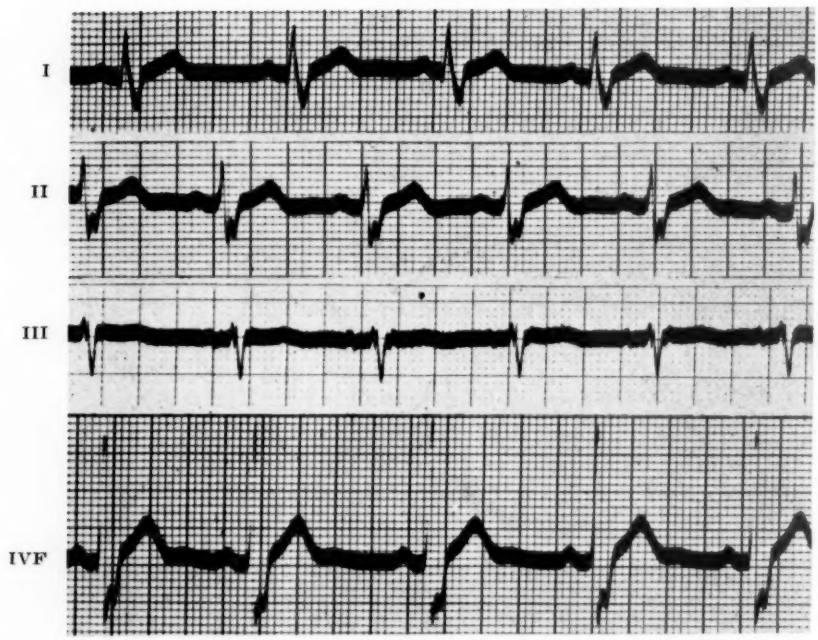

Fig. 10.—After stimulus.

3. QRS complexes of 0.12 second duration, even when observed in the electrocardiograms from young, apparently healthy persons, are usually caused by some abnormality but in rare instances may not have any pathologic signficance.

4. The duration of QRS has been observed to increase temporarily as the result of a fright stimulus.

THE Q WAVE

In Lead I, omitting three records showing abnormal rhythm, there were 511 instances of a definite negative deflection preceding the R, six instances in which a tiny upstroke preceded Q (R^1 new terminology), 23 instances of a heavy slur at the beginning of the upstroke of R (fused Q wave), and 456 instances in which R was not preceded by another wave. The amplitude of Q in the 511 instances where it was a single negative deflection ranged from –0.1 to –3, and the mean was –0.54. The amplitude of Q equalled 7.8 per cent of the amplitude of R_1 on the average, and the range was from 0.8 to 33 per cent. The amplitude of Q_1 equalled 5.6 per cent of the amplitude of the tallest R in any of the three standard leads on the average, and the range was from 0.6 to 25 per cent. Thus, in Lead I, Q was never found to be greater than 3 mm. in amplitude, and it was never more than 33 per cent of the amplitude of the R in that lead or more than 25 per cent of the amplitude of R in any lead. There were only three instances where Q_1 was 20 per cent or more of the tallest R in any lead.

In Lead II there were 681 instances of a definite negative deflection preceding the R, eight instances in which a tiny upright wave preceded the Q (R^1 new terminology), 56 instances of a heavy slur at the beginning of the upstroke of R (fused Q wave), and 260 instances in which R was not preceded by any other wave. The amplitude of Q in the 681 instances where it was a negative deflection ranged from –0.1 to –3.5 and the mean was –0.73. The amplitude of Q_2 equalled 6 per cent of the amplitude of R_2 on the average and ranged from 0.6 to 50 per cent. The amplitude of Q_2 equalled 5.8 per cent of the amplitude of the tallest R in any of the three leads on the average and ranged from 0.6 to 50 per cent. Thus, the maximum amplitude of Q in Lead II was 3.5 mm., but in only three instances was it 20 per cent or more of R in the same lead.

In Lead III there were 677 instances of a definite downward deflection preceding the R, 61 instances where a tiny upright deflection preceded the first important deflection in QRS (R new terminology), 92 instances of a heavy slur at the beginning of the upstroke of R (fused Q wave), 33 instances where the QRS consisted of so many deflections that a definite Q could not readily be identified, and 134 instances in which no Q wave was seen. The amplitude of Q in the 677 instances where it was a negative deflection ranged from –0.1 to –4.5 mm., and the mean

was –1.04. The amplitude of Q_3 equalled 14.8 per cent of the amplitude of R_3 on the average, and the range was from 0.7 to 150 per cent. There were 26 instances where Q_3 was equal to one-half or more of the amplitude of R_3. The amplitude of Q_3 equalled 8 per cent of the amplitude of the tallest R in any of the three limb leads and the range was from 0.6 to 60 per cent. There were 18 instances where Q_3 was equal to one-fourth or more of the amplitude of the tallest R in any lead.

THE R WAVE

In Lead I, omitting the three instances of abnormal rhythm, the R waves were always upright and ranged in amplitude from 1 to 16.5 mm., with a mean value of 5.9 mm. There were 62 instances where R_1 was between 10 and 16 mm. in amplitude.

In Lead 2 the R waves were always upright, ranging in amplitude from 1.3 to 26 mm. and with a mean value of 11.6 mm. There were 152 instances in which the amplitude was from 15 to 19.9 mm., and 29 instances in which it was from 20 to 26 mm.

In Lead III the R waves were upright in 946 instances, ranging in amplitude from 0.5 to 24 mm. with a mean of 7.2 mm. In the remaining 61 instances QRS was described as a vibratory complex or inverted.

THE S WAVE

In Lead I, again omitting the three cases showing abnormal rhythm, there were 856 instances of a definite negative deflection following the R wave, six instances in which there was a tiny upright wave following the last important QRS deflection (R^2 new terminology), 39 instances of a heavy slurring at the end of the downstroke of R (fused S wave), and 99 instances in which R was not followed by another wave. The amplitude of S in the 856 instances where it was a negative deflection ranged from –0.1 to –6.3 mm., and the mean was –1.74 mm. The amplitude of S_1 equalled 39.5 per cent of the amplitude of R_1 on the average, and the range was from 0.9 to 266.7 per cent. The amplitude of S_1 equalled 16.2 per cent of the amplitude of the tallest R in any of the three limb leads on the average, and the range was from 0.5 to 90 per cent. Thus, in Lead I, S waves as great as 6.3 mm. in amplitude were observed, and in 21 instances (excluding records with right axis deviation) S was 4 mm. or more in amplitude.

In Lead II there were 749 instances of a definite downward deflection following the R wave, eight instances in which there was a tiny upright wave following the last important deflection of QRS (R^2 new terminology), 109 instances of a heavy slurring at the end of the downstroke of R (fused S wave), and 138 instances in which S was absent. The amplitude of S in the 749 instances where it was a downward deflection ranged from –0.1 to –9 and the mean was –1.78. The amplitude of S_2 equalled 20.3 per cent of R_2 on the average and ranged from 0.6 to 200 per cent.

The amplitude of S_2 equalled 18.4 per cent of the tallest R in any of the three limb leads on the average and ranged from 0.6 to 143 per cent. Thus, S in Lead II was observed to be as much as 7 mm. in amplitude and was sometimes over twice the amplitude of R_2 and greater than the amplitude of R in any lead (Fig. 11). S_2 was greater than 4 mm. in amplitude in 24 instances, excluding cases of right axis deviation.

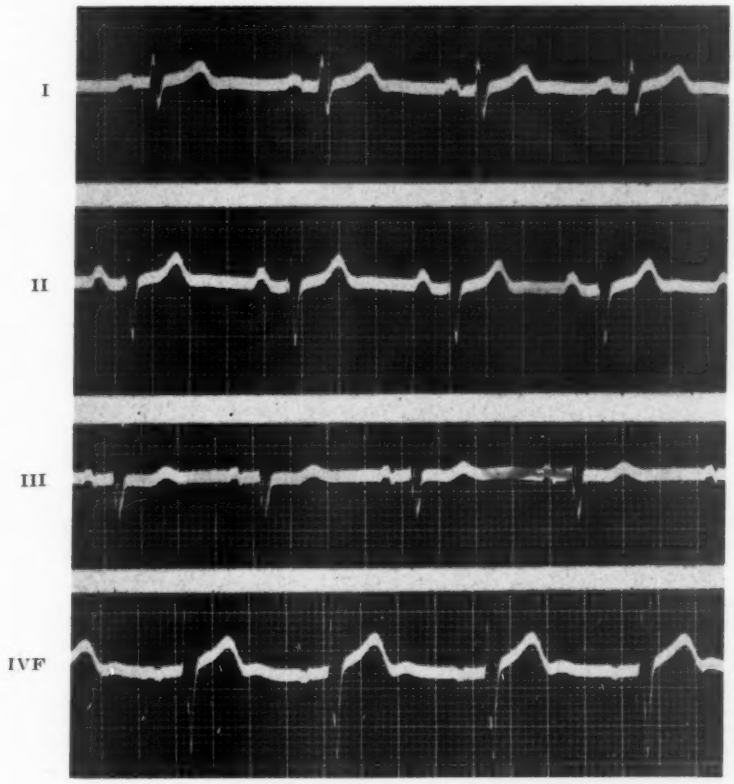

Fig. 11.—Prominent S waves.

In Lead III there were 527 instances of a definite negative deflection following the R wave, 12 instances in which a small upright wave followed the last main QRS deflection (R^2 new terminology), 117 instances of a heavy slur at the end of the downstroke of R, 346 instances in which S was absent or the QRS complex was inverted or vibratory. The amplitude of S in the 527 instances where it was a definite downward deflection ranged from –0.1 to –12 mm. with a mean of –1.48 mm. The amplitude of S_3 equalled 43.5 per cent of R_3 on the average, the range being 0.6 to 500 per cent, and equalled 15.8 per cent of the tallest R in any lead on the average, with a range of 0.6 to 160 per cent. Thus in Lead III, S was found to be as much as 12 mm. in amplitude and as much as five times the amplitude of R in that lead and nearly twice the amplitude of R in any lead.

FORM OF QRS

There was no instance of notching of the Q, R, or S waves in Leads I and II but there was slight slurring of R_1 in 23 instances and R_2 in 35. Slurring and occasional notching were frequently observed near the base line especially when the voltage of the waves was low. In Lead III, R was slurred in 80 instances and notched in 17. A vibratory QRS complex was not observed in Leads I and II, but was observed in 52 instances in Lead III. The QRS complex was "inverted" in 25 instances in Lead III but not in Leads I and II except for the inversion of Lead II associated with left axis deviation.

There were 16 instances where the greatest amplitude of any deflection of QRS in the standard leads was no greater than 5 mm. and 70 instances where the amplitude was from 5.1 to 7 mm. The small incidence of low voltage of QRS in this series contrasts sharply with the much greater incidence found in a smaller but older group of pilots.[1] The large amplitude of QRS in young persons is a well-known fact. An account of the incidence and significance of low voltage may be found in the recent papers of Leach, Reed, and White[16] and Bellet and Kershbaum.[17]

THE ELECTRICAL AXIS

The angle of the electrical axis of the electrocardiogram was calculated according to the method of Carter, Richter, and Greene[18] for all records except those where the QRS duration was greater than 0.11 second. The range was from +120 degrees to –36 degrees and the mean angle was 64.2 degrees. The "normal" axis is sometimes stated to lie between 0 and 90 degrees but many observers have found the extremes to be much greater. From a consideration of the significance of this angle it is apparent that it may vary within wide limits in the electrocardiograms from persons with normal hearts.

Various indices have been proposed as rough guides to the degree of axis deviation and the one used here is that proposed by White,[19] namely, Index $= (R_1 + S_3) - (R_3 + S_1)$. The range was found to be from +23 to –21 and the mean –2.25. White gives the normal range as lying between +30 and –15.

Left axis deviation was considered to be present when the algebraic sum of $R_1 + S_1$ was positive and the sum of R_3 and S_3 was negative, and R_1 was greater than R_2.[20] There were 51 instances in which these criteria were fulfilled. A ratio was obtained by dividing the amplitude of R by the amplitude of S in Lead II; the values ranged from 0.3 to 17 with a mean of 4.17. There were 21 instances of "inversion of Lead III," i.e., the P wave, the chief initial ventricular deflection and the T wave, were all downwardly directed. There were no instances in which the S-T segments were displaced in an opposite direction from the chief initial deflection in Leads I and III.

Right axis deviation was considered to be present when the sum of R_1 and S_1 was negative, the sum of R_3 and S_3 positive, and R_3 was greater than R_2. There were 22 instances in which these criteria were fulfilled. The ratio of R_2/S_2 ranged from 1.1 to 17.6 and the mean was 6.8. There were no instances in which the S-T segments were oppositely displaced from the chief initial deflections in Leads I and III.

In summary, then, it is seen that in young, healthy persons without hypertension and without cardiac enlargement which can be detected by clinical and x-ray examination (A-P teleroentgenogram of chest), the electrical axis of the electrocardiogram may vary within a wide range. In some instances the S waves in Lead II may be as great or greater in amplitude than R, but the S-T and T-wave changes associated with ventricular preponderance are not observed.

S-T JUNCTION AND S-T SEGMENT

The displacement of the S-T junction was measured and the various forms of the S-T segment classified. The S-T junction was considered to be the point of union between the QRS complex and the S-T segment or the T wave and the reference level the P-Q segment. The S-T segment was considered to be (1) ascending, (2) concave, (3) convex, and (4) flat.

TABLE VII

DISPLACEMENT OF THE S-T JUNCTION IN THE STANDARD LEADS

		N	MEAN (MM.)	RANGE (MM.)	NUMBER GREATER THAN 1 MM.
Lead I	upward	854	+0.41	+0.1 to +1.5	5
	none	137			
	downward	9	-0.64	-0.1 to -1.2	1
Lead II	upward	890	+0.62	+0.1 to +2.0	30
	none	98			
	downward	12	-0.46	-0.1 to -1.0	0
Lead III	upward	460	+0.43	+0.1 to +1.5	7
	none	463			
	downward	77	-0.33	-0.1 to -1.5	1

Table VII shows the incidence of the upward and downward displacement of the S-T junction in the three standard leads. The particular points of interest are the rarity with which the S-T segment was downwardly displaced and the fact that occasionally it may be displaced upwardly more than 1 mm. from the base line.

The incidence of the various forms of the S-T segment is shown in Table VIII. It is difficult to describe this segment, and the classification into the various forms is unsatisfactory. This is true for many reasons, including the fact that there are many degrees of variation within a given general pattern, the presence of mixed forms, and the failure to take into account the level of the S-T junction and the form of the T wave.

TABLE VIII

FORM OF S-T SEGMENT IN THE STANDARD LEADS

FORM OF S-T SEGMENT	PERCENTAGE		
	LEAD I	LEAD II	LEAD III
Ascending	13.4	12.9	3.5
Concave	76.9	79.7	45.4
Convex	0.2	0.0	2.3
Flat	9.5	7.4	48.8

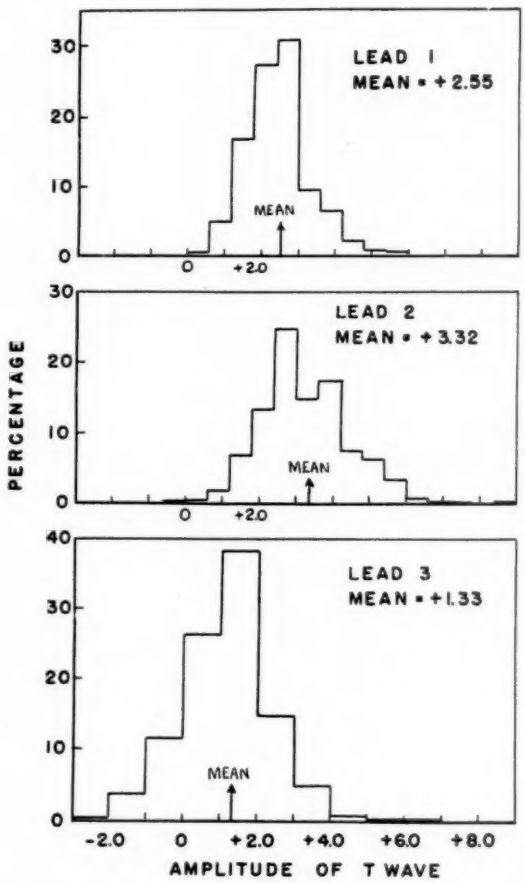

Fig. 12.—Percentage distribution of the various amplitudes of T in the standard leads.

THE T WAVE

The data pertaining to the duration and amplitude of the T waves in the three standard leads is summarized in Table IX and Fig. 12. There was not a single instance of inversion of T in Lead I, omitting the three records with abnormal rhythm, but T was sometimes low (Fig. 13). In Lead II there were only two instances of inversion of T (Figs. 14 and 15), and one of diphasic T. In Lead III, T was inverted or

diphasic in over one-fifth of the records. The T waves in all three leads were not greater than +1 mm. in two records and +2 mm. in 119 records.

TABLE IX

AMPLITUDE OF THE T WAVE IN THE STANDARD LEADS

	N	MEAN (MM.)	MODE (MM.)	RANGE (MM.)	NUMBER INVERTED	NUMBER DIPHASIC
Lead I	988	+2.55	+2.80	+0.2 to +6.0	0	0
Lead II	989	+3.32	+2.80	−0.8 to +8.5	2	1
Lead III	974	+1.33	+1.50	−2.6 to +6.0	150	90

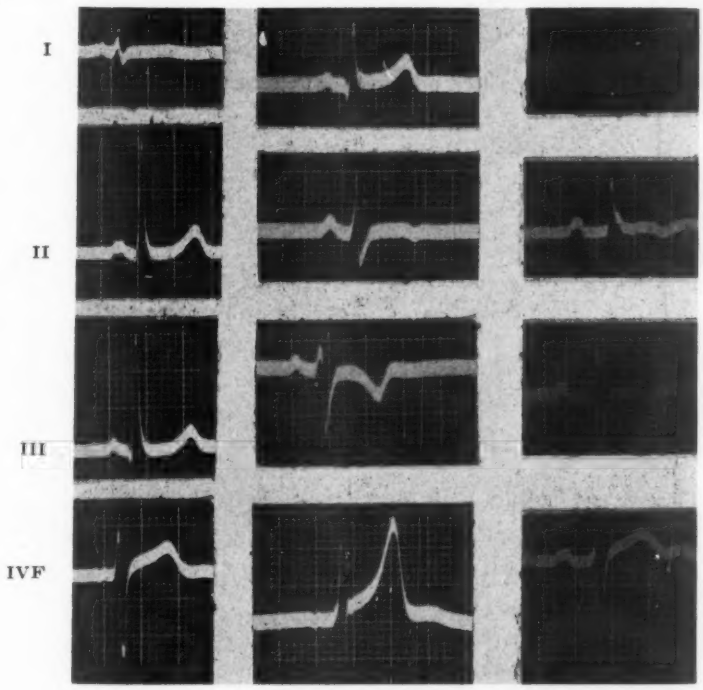

Fig. 13.—Low T_1. Fig. 14.—Inverted T_2T_3. Fig. 15.—Inverted T_2T_3.

These results emphasize the rarity of finding low or inverted T waves in Leads I and II in the electrocardiograms obtained from healthy persons of normal build, lying supine. Recently, considerable attention has been given[21, 22] to the exceptions to the rule that the T waves are normally upright in Leads I and II. These exceptions are important and deserve emphasis, but it must be remembered also that they occur infrequently and are usually due to some well-recognized cause, such as elevation of the left diaphragm, and the upright position.

THE Q-T INTERVAL

The Q-T interval was calculated according to the formula $Q\text{-}T = K\sqrt{\text{cycle length}}$. The range was from 0.30 to 0.59 and the mean 0.383.

THE U WAVE

The incidence of the U waves in the three standard leads and their direction and amplitude are shown in Table X. The fact that only two instances of inverted U waves were observed lends support to the generally accepted opinion that inversion is abnormal.

TABLE X

INCIDENCE AND AMPLITUDE OF U WAVES IN THE STANDARD LEADS

INCIDENCE OF U WAVES	
LEAD	NUMBER
1	268
2	448
3	141
1 and 2	131
1 and 3	14
2 and 3	66
1, 2, and 3	50
One Lead Only	284
No Leads	438

AMPLITUDE OF U WAVES				
	N	MEAN (MM.)	RANGE (MM.)	NUMBER INVERTED
Lead I	268	+0.12	+0.1 to +0.3	0
Lead II	448	+0.14	+0.1 to +1.0	0
Lead III	141	+0.13	+0.1 to +0.3	2

LEAD IVF

Lead IVF was obtained in all but six instances. The precordial electrode was placed on the chest at the outer border of the apex beat when this could be palpated, otherwise in the fifth intercostal space at the outer border of cardiac dullness. The left leg lead wire was attached to the precordial electrode and the left arm wire was attached to the electrode on the left leg.

The P Wave.—The P wave was visible in 967 of the 994 records. It was upright in 508 instances, ranging in amplitude from 0.1 to 1.5 mm., with a mean of 0.43. P was inverted in 126 instances and diphasic in 249. It was barely perceptible or small and bizarre in shape in 71 instances and absent in 40.

QRS Duration.—The duration of QRS ranged from 0.06 to 0.14 second, with a mean of 0.086. Although the range is the same and the mean value only 0.001 second smaller than for the maximum QRS duration in the limb leads, it does not follow that the values were the same in a given record. Frequently, the duration of QRS differed by 0.01 or 0.02 second in the limb and chest leads, but, on the average, it was not found to be longer in the chest leads as is sometimes stated.

The Q Wave.—In 795 records a Q wave was not seen; in 34 it was tiny and upright; in 45 it was represented by a slur at the base of the upstroke of R (fused Q); in 120 it was downwardly directed, ranging in value from –0.1 to –5.0 mm., with a mean of –0.83; Q was greater than

–1 mm. in 22 instances. Prominent Q was often associated with small S, tall R, and relatively great upward displacement of S-T, thus raising the suspicion that the precordial electrode was not properly placed over the cardiac apex.

The R Wave.—The R wave was always upright and ranged in amplitude from 1 to 29 mm. with a mean of 10.4. It was slurred in 82 instances and notched in 69. Thus, slurring and notching does not have the same significance as it does in Leads I and II where normally it is less commonly observed.

The S Wave.—This wave was absent in six instances, represented by a slur at the base of the downstroke of R in 11, and, in the remainder, varied from –0.2 to –28 mm. with a mean of –9.3. S was notched in 31 instances and slurred in 27.

The S-T Junction.—The S-T junction was displaced upward in 977 of the 994 records and in the remainder it was either downwardly displaced (three instances) or at the isoelectric level. The upward displacement varied from 0.1 to 5 mm. with a mean of 1.14. The extreme degree of displacement was associated with a small S wave (or no S) and may have been due to improper placing of the chest electrode.

The T Wave.—The T wave was upright in all but two instances, where it was diphasic; the range was from 1 to 15 mm., and the mean was 5.9. T was greater than 10 mm. in amplitude in 25 instances. Huge T waves have been shown[23] to be of pathologic significance in some cases. They are rarely observed in the electrocardiograms from healthy persons.

The U Wave.—The U wave was never found to be inverted and was present and upright in 915 of the 994 records. The range was from 0.1 to 1.2 mm., and the mean 0.24 mm.

LEAD IVR

Lead IVR was obtained in all but eleven cases. It was always taken immediately after Lead IVF was recorded, and the change in galvanometer connections was effected by simply turning the lead-selector switch. Thus, the two chest leads were taken under identical conditions.

The P Wave.—The P wave was always visible. It was upright in 976 instances and the value ranged from 0.1 to 2.3 mm. with a mean of 1.15. In the remaining 13 instances the P waves were inverted or diphasic.

The QRS Duration.—The duration of QRS varied from 0.06 to 0.14 second, and the mean was 0.087.

The Q Wave.—In 196 instances a downwardly directed Q was observed, which ranged in amplitude from 0.1 to 6.0 mm., with a mean of 0.80. In 38 of the 196, Q was more than 1 mm. Improper placing of the chest electrode was probably responsible for the extremely prominent Q waves. In 35 instances a tiny upright Q (R^1 new terminology) was

observed, and in 11 instances Q was represented by a slur at the base of the upstroke of R. In the remaining 747 records Q was not seen.

The R Wave.—The R wave was always upright and ranged in amplitude from 1.3 to 38 mm., with a mean of 17.8 mm.

The S Wave.—The S wave was downwardly directed in all but 23 instances, and the amplitude varied from –0.2 to –28 mm., with a mean of –8.34. Of the 23 remaining, 16 were fused, three were tiny but upright, and in four instances S was not seen.

S-T Junction.—The S-T junction was upwardly displaced in all but seven records; the range was from 0.6 to 4.5 mm. and the mean was 1.57 mm. In two records there was no displacement and in five there was slight downward displacement.

The T Wave.—The T waves were always upright and varied in amplitude from 2 to 22 mm., with a mean of 8.79.

The U Wave.—The U wave was present and upright in all but 20 records, where it was not seen. It varied in amplitude from 0.1 to 1 mm., with a mean of 0.28 mm.

COMPARISON OF LEADS IVF AND IVR

Some electrocardiographers have expressed a preference for the use of IVR rather than IVF. A comparison of the two, in so far as normal records are concerned, suggests that Lead IVF has one advantage; namely, that the amplitude of the several waves is smaller, which affords a more convenient normal range. In all other respects there seems to be no advantage either way.

DISCUSSION

The interpretation of an electrocardiogram ordinarily involves three distinct steps, namely, (1) the actual measurement of the various component parts, (2) the recognition of any deviations from the normal, and (3) a proper evaluation of the significance of the findings. The first step is essentially objective, if carried out in accordance with established procedure. The second step requires a thorough knowledge of the normal electrocardiographic patterns gained from past experience. The third step requires a full knowledge of the significance of the various deviations from the normal, together with a careful correlation with the other findings in the case. This part of the interpretation is largely subjective and reflects the judgment of the interpreter.

The need for information regarding the normal has led to an extensive study of the electrocardiograms obtained from healthy persons. Early studies* were carried out on only a small number of subjects, and the results did not disclose the full extent of the normal range. This, not infrequently, led the electrocardiographer wrongly to regard a par-

*See standard textbooks for references.

ticular measurement as abnormal and, as a consequence, to err in assessing its significance. More recent studies, including our own, involving large numbers of healthy subjects, have shown more completely the extremes of the normal range. The possibility that a few of the subjects in the present series had cardiac defects which could not be detected by ordinary methods of examination is freely admitted, but the number must have been very small. A follow-up study is, unfortunately, impossible at this time.

The results show that, even in a select group of young men, the electrocardiograms may vary within wide limits. The variations observed would undoubtedly have been greater if the subjects had included members of both sexes, with greater differences in body build, and if the subjects had been seated rather than lying when the records were obtained.

With regard to most of the electrocardiographic measurements, it is obvious that there is a considerable degree of overlap between the range of the normal and abnormal, and that there is no sharp dividing line between the two. This is responsible for one of the most important limitations of the usefulness of the electrocardiographic method. For certain electrocardiographic measurements it is necessary to know whether a given value falls clearly within the normal or abnormal range or in a middle or ambiguous range. If it falls in the ambiguous range, the probability that it is abnormal increases with progression from the normal to the abnormal. For example, in young adults, if the P-R interval is between 0.12 and 0.18 second, it is very likely to be normal; between 0.18 and 0.22 second it may be normal or abnormal, but the likelihood of its being abnormal becomes greater with each 0.01 second increase above 0.18. Serial electrocardiograms are helpful in that a definite change may indicate, in an individual case, the dividing line between the normal and abnormal even though both values lie within the so-called normal range.

It may not be out of place here to express an opinion regarding the usefulness of electrocardiography in aviation medicine. Failure of the circulation may be the limiting factor in man's adaptation to the sometimes exacting and abnormal influences of flying. Consequently, the physician responsible for the care of flyers will frequently be called upon to evaluate their cardiovascular status. In such an evaluation the electrocardiogram will often be helpful. This is true even when young, apparently healthy persons are concerned as shown by the findings in the present study. It becomes increasingly true as the flyers grow older and become subject to degenerative heart disease. The value of serial electrocardiography is also apparent, especially when the first tracings are taken when the subjects are young. Establishing a "normal" base line often aids in the interpretation of records

obtained at a later date. Naturally, the usefulness of this method in aviation medicine will vary greatly with the nature of the flying to be done.

SUMMARY AND CONCLUSIONS

1. The results of an analysis of the electrocardiographic findings in 1,000 young aviators have been presented.

2. The aviators represented a highly selected group of men between the ages of 20 and 30 years. None had any cardiac defect on physical and x-ray examination. The electrocardiograms (Leads I, II, III, IVF, and IVR) were taken with the subject recumbent and, with a few exceptions, in the basal state. The various measurements obtained from the tracings were recorded on master sheets and then analyzed statistically.

3. The results serve to emphasize the great individual variation in the electrocardiographic pattern and the wide range of normal values. These findings have been presented in detail with the aid of tables and charts.

4. Even after rejecting as frankly abnormal some of the extreme values observed, it is apparent that the "normal" extends well into what has commonly been regarded as the abnormal range. Some idea of the probability of a given value being abnormal is gained from the frequency with which it has been found to occur in normal persons.

5. The relatively large number of interesting and important electrocardiographic findings observed in young and apparently healthy aviators suggests that electrocardiography is of considerable value as an aid in the medical examination of pilots.

We wish to express our thanks to Dr. Paul D. White for his advice and critical review of the manuscript, and to Miss Helen M. Mitchell for her assistance in compiling the electrocardiographic data.

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SOME OBSERVATIONS ON THE CARDIOVASCULAR EXAMINATION FOR AIRCREW FITNESS

DONAL P. MURNAGHAN, M.D.*
FLIGHT LIEUTENANT, R.C.A.F.

WARTIME training of aircrew demands the largest number of well-trained personnel in the shortest time. Selection, therefore, becomes an important factor in eliminating wastage. Educational and aptitude tests have been combined with a strict medical examination in an effort to weed out the unfit and those whose chances of succeeding in operational flight are minimal for one reason or another. For preference, aircrew should be intelligent persons, medically fit, and endowed with skill, courage, and high spirits. As the strain of war reduces available man power, poorer types become applicants for the great fight. Some are highly motivated but have a poor constitution; others are driven by circumstances, the Army Draft, or by the derision and criticism of their neighbours. It is essential that considerable judgment be used so that valuable material be not lost by too strict adherence to meticulous medical standards.

In this war, experience has taught us that "Nature rather than nurture" seems to produce both the apt and the inapt pupil flyer. The cardiovascular system in relation to aircrew fitness surely reflects the gifts of Nature, and its reactions to the physical circumstances of flight have been much studied. Some observations on the normal variations in heart shape, heart sounds, heart action, and the place of the electrocardiogram and neurovascular instability in relation to the examination for aircrew fitness are presented in this paper. A more complete review is not attempted.

Heart Shape.—One can obtain by physical examination a fair appreciation of the position and size of the heart in the age group of potential aircrew (18 to 35 years). Routine 2 meter roentgen films of the chest are available to supplement the clinical observations. For proper interpretation of the film it should be appreciated that the shape of a normal heart is not limited to the classical forms of many texts. The normal frontal heart shadow varies in appearance over a wide range from long and narrow to being broad and transversely placed; the normal lateral or oblique views also vary considerably from deep to relatively shallow: a prominent pulmonary artery or a straight-line left cardiac border may be present in a normal person (1) with a long thin chest, or if the heart is (2) rotated anticlockwise on its long axis, or (3) displaced by slight scoliosis or sternal depression. In all such

*Former Special Research Fellow in Cardiology, Massachusetts General Hospital, Boston, Mass.

cases, however, careful search for the diastolic rumble of mitral stenosis at the apex, or other pathologic causes of increase in the left middle arc, should be made. Inaccurate alignment of the tube, subject, and film creates a shadow which is really a view slightly oblique to one side or the other of the straight P-A film. A routine check of each chest film for proper centering before interpretation is therefore strongly recommended.

Radiologists with experience in examining large numbers of recruits with supposedly normal hearts do not favor fixed standards for normal heart size. Measurements, nevertheless, are a valuable yardstick in the diagnosis of cardiac enlargement. The transverse diameter, the area of the frontal heart shadow, and the cardiothoracic ratio are those most frequently used. Where only one examination of the heart may be made, the frontal cardiac area is the most sensitive index of heart size. For repeated examinations on the same heart Comeau and White[1] have pointed out the simplicity and precision of the transverse diameter measurement in preference to the others. Standards based on weight and height have been established for the transverse diameter, Hodges and Eyster[3] for orthodiagraphy, and Ungerleider and Clark[7] for the teleoroentgenogram. A nomogram chart prepared by Ungerleider and Gubner[8a] permits the frontal area to be read directly from the long and broad cardiac diameters. Values exceeding 10 per cent above the predicted reading, from weight and height for the frontal area and transverse diameter, are usually abnormal.

Among the candidates for aircrew, an athlete of some experience may present roentgenologic evidence of slight cardiac enlargement according to accepted standards. In a recent article, Wilce[11] suggests that the intangible factors frequently found in true athletes, such as superior volitional trends and superior competitive spirit, may far outweigh the theoretical consideration of a relative anoxia in an hypertrophied heart at high altitudes. The modern use of oxygen above 10,000 feet definitely supports his inference that such cases might well be accepted for aircrew training. In the absence of etiological evidence of heart disease, and with normal physical findings, electrocardiogram, and exercise tolerance, it is suggested that values up to +15 per cent increase in the frontal area may be accepted for aircrew.

Heart Sounds.—Any attempt to judge the efficiency of the heart from the intensity of its sounds is fallacious. In healthy young airmen the variation in normal heart sounds is considerable. Detection of the minor differences depends to some extent upon the training and attention of the examiner. An impure quality or actual reduplication of the first heart sound at the apex or reduplication without accentuation of the second sound over the pulmonary area are not infrequent; change of posture or respiratory phase often corrects the sound to a normal single quality. A low third heart sound may normally be pres-

ent at the apex in thin persons, especially in the recumbent or left lateral position. Midsystolic clicks or sounds are ordinarily inconsequential.

Rarely, the low-pitched sound of auricular contraction may be heard before the first heart sound. This sound is not normally audible. Prolongation of auriculoventricular conduction time or complete heart block are the commonest causes. If an unstable auriculoventricular conduction time is present where the P-R interval varies with change in posture,[5] careful auscultation may elicit audible auricular contraction.

The first heart sound is frequently of low intensity when the P-R interval is at the upper limit of normal or slightly prolonged. This clinical finding has been confirmed repeatedly. One explanation is based on the theory that closure of the auriculoventricular valves contributes the significant energy in producing the first heart sound.[4] When auriculoventricular conduction is prolonged, ventricular filling has nearly been completed, and the valve cusps have already floated into apposition when isometric ventricular contraction begins. The auriculoventricular valves do not then close as vigorously as they ordinarily do. Proponents of muscular contraction of the ventricles as the primary basis of the first heart sound suggest that ventricular filling is already above normal when isometric contraction begins, and the pressure gradient within the ventricle is not increased as rapidly as usual. The vigor of the muscular contraction according to the latter theorists is a measure of the sound it is claimed to produce.

The presence of a systolic murmur in a candidate for aircrew, calls for careful interpretation. Systolic murmurs in normal persons occur more frequently than is commonly recognized. In a study of 100 airmen free from heart disease, examined personally, four-fifths showed on a stethogram a systolic murmur of some kind when recumbent; pulmonic murmurs were slightly favored. The murmurs were loudest during expiration and in the supine position; they disappeared during inspiration and in most cases disappeared or were diminished on assuming the erect position.

In aircrew, systolic murmurs which vary with change in posture and disappear during some phase of the respiratory cycle, usually in inspiration, may be disregarded. Recognition of the etiological cause underlying a murmur is so much more important than the mere physical dynamics creating it. In this regard, the classification of cardiac murmurs into physiologic and pathologic types[10] is considered superior to the traditional terms "functional" and "organic." Venous hums originating in, or transmitted into, the innominate veins are also physiologic variations. If maximal to the left of the sternum below the sternoclavicular junction, they may be mistaken for the continuous "machinery" murmur of patent ductus arteriosus. Digital pressure on the internal jugular vein causes a venous hum to disappear. A loud systolic murmur and occasionally a thrill is sometimes heard below the lateral half of the clavicle and is due to compression of the corre-

sponding subclavian artery as it passes over the first rib. Cardiopulmonary systolic murmurs caused by compression of aerated lung substance during movement of the heart are unimportant except in their recognition and differentiation from pathologic murmurs. An increased rate of blood flow or anemia may cause a systolic murmur secondarily.

When a systolic murmur persists during all the common maneuvers in physical diagnosis, it is the result of some pathologic cause, such as rheumatic endocarditis, congenital anomaly, or dilatation of the valve ring. Candidates with recognized heart disease are unfit for service. If a slight but persistent murmur is the only finding and a negative or doubtful etiological history is obtained, the question of fitness for aircrew duties arises. Some argue that since the physical duties of an aviator are much less strenuous than those of the foot soldier, he may be accepted. The chance of recurrent rheumatic fever, the commonest etiological cause, or the possibility of subacute bacterial endocarditis make such a person a greater hazard in military service than one of sound health. Nevertheless, it is felt that medical standards could be judiciously relaxed in such cases and render valuable material available for aircrew.

Murmurs are an important diagnostic clue in congenital heart disease. The cyanotic forms of congenital heart disease are not acceptable for service. In principle, the acyanotic types should be rejected if recognized. History, physical examination, an electrocardiogram, and a roentgen chest film may each contribute information which will help in establishing the diagnosis. Many slight cases are missed even by experienced observers.

Heart Action and Function.—Meticulous adherence to fixed standards of pulse rate and blood pressure when assessing fitness for aircrew can also cause the loss of valuable personnel. The candidate, a volunteer for aircrew duties, is influenced by various emotional factors when he appears before the examining physician. Reassurance, rest in a quiet room, and, if necessary, re-examination on another day are strongly recommended if the readings are above the accepted standards. Aircrew standards have been adopted which allow considerable latitude. Pulse rates over 84 per minute are carefully investigated, and rarely is a person accepted with a persistent rate of 100 per minute or higher. The highest acceptable blood pressure is 145/95. At the lower range, pulse rates below 50 per minute and blood pressures below 100/60 are investigated. If asymptomatic and otherwise normal, persons with these and even slightly lower readings are acceptable. Some persons are unusually sensitive to the physician's presence and do not relax easily. In such cases a reliable technical assistant may find the pulse and blood pressure within normal limits when they were persistently elevated during repeated examinations by the physician. The wide range of normal pulse rate at rest or relative rest, in White's personal experience, ranges from 38 to 118 per minute.[9]

Table I shows some personal observations on 120 healthy young men. The mean systolic blood pressure was significantly lower when the emotional factor of the medical test was removed.

TABLE I

	AT TIME OF ROUTINE MEDICAL EXAMINATION	TWO HOURS LATER WHEN EMOTIONAL FACTOR OF EXAMINATION WAS REMOVED
Pulse rate	75.44	75.90
Standard deviation	±8.24	±8.90
Systolic blood pressure	123.99	113.70
Standard deviation	±11.50	±10.48
Diastolic blood pressure	76.59	76.33
Standard deviation	±8.70	±7.98

The individual whose blood pressure descends with difficulty to 145/95 may be a potential hypertensive. This fact does not necessarily affect his ability to fly, and such persons often make good pilots. Persons with a blood pressure of 100/60, without symptoms and with a good exercise tolerance, are acceptable. A history of postural vertigo and frequent fainting attacks entails rejection, more especially if postural hypotension is recognized in addition.

Exercise tolerance tests in some form have long been used as a measure of cardiovascular efficiency and physical fitness. It has been demonstrated to our satisfaction that no one of these tests uniformly measures the physical fitness of the individual and they are at best an uncertain index of cardiovascular efficiency.

For twenty-five years in the examination for aircrew, the candidate has been requested to maintain a column of mercury 40 mm. in height by respiratory compression as long as he can, and the pulse rate has been noted in five-second intervals. Considerable importance was originally attached to the nature of the pulse-rate curve, a low level sustained through 60 seconds being the best type. From correlation studies it is now known that the type of curve is not an effective selector of potential aircrew; the test is still used but interpreted as one of endurance, stamina, and spirit, "when the going gets difficult." In this regard 55 seconds is considered a critical level.

Variations in Rhythm.—Sinus tachycardia (rate above 100) should be evaluated as accurately as possible. Nervousness or excitement is responsible for most cases, but infection, fever, fatigue, and mild hyperthyroidism should not be overlooked. When it forms part of a mild autonomic instability, statistics show that the candidate stands an average chance of finishing his course but is usually considered inferior combat material. Further reference is made to this subject later.

Sinus bradycardia (rate below 55) is not uncommon. A history of recent infection, such as influenza, may be elicited. All doubtful cases should have an electrocardiogram as part of their investigation.

Sinus arrhythmia is very common and may be disregarded in the young applicants for aircrew. If marked and associated with occasional premature beats, the resulting arrhythmia may be difficult to distinguish by clinical examination. An electrocardiogram is recommended in such cases.

In general, the candidate with a history of paroxysmal tachycardia with symptoms should not be in aircrew. This is commensurate with the importance of his post and the strain of his duties. Unless incapacitated by frequent attacks, he can be profitably employed in a noncombatant position on the ground. If the trained pilot complains of symptoms due to palpitation or of a paroxysm of tachycardia, he may be using a lever to avoid operational duty or he may simply be worried about his ability to continue flying. General principles are applicable in the latter case; if he has incapacitating symptoms during the attack, no matter how short, he should not hold a position which would endanger the lives of his crew or the loss of an aircraft. A few well-chosen questions may elucidate an underlying psychological situation in the former instance.

The commonest arrhythmias seen in potential aircrew are due to premature systoles. It is frequently possible to distinguish them by clinical examination, but an electrocardiogram is recommended if they are frequent. Occasional supraventricular or ventricular premature contractions may be disregarded. If occurring with moderate frequency, an attempt should be made to find the cause and to remove it if possible. Any candidate with electrocardiographic confirmation of (a) short runs of premature beats, (b) multiple foci of premature auricular or ventricular contractions, (c) premature beats with a heart rate above 110 per minute, (d) increase in the number of premature beats after exercise, and (e) inversion of the T wave in the postextrasystolic contraction in the electrocardiogram[8b] should be rejected. Abnormal ectopic rhythms are not acceptable for military service.

Electrocardiography.—The place of electrocardiography in aircrew selection is not easy to evaluate accurately. In a routine series of apparently healthy aircrew candidates, only 0.45 per cent of definitely abnormal tracings were found.[2] Although considerable economy is realized in early rejection of even such a few persons, it would scarcely seem justifiable to record electrocardiograms routinely on all potential aircrew. Electrocardiography does serve a very useful purpose, however, in selected cases in young persons and is recommended as a routine part of the examination of all aircrew personnel over 35 years of age.

Some interesting variations have been recorded in routine series of electrocardiograms. They include the "short P-R, wide QRS" picture first described by Wolff, Parkinson, and White,[12] sinus bradycardia at a rate of 38 per minute and alteration in the auriculoventricular

conduction time with change in posture,[5] the P-R interval being prolonged when in the recumbent or head-down position.

For selection purposes, if the electrocardiogram indicates myocardial damage or impairment of the conducting tissues, the candidate should be rejected. Complete heart block or bundle branch block (QRS, 0.12 second or longer) is cause for rejection. An asymptomatic short P-R, wide QRS syndrome does not entail rejection. Persistent prolongation of the P-R interval up to 0.28 second is occasionally found in normal healthy persons. It does not appear to be any particular hazard in the air, yet one hesitates to accept such a candidate. Under present standards they are unfit for aircrew. Cases are known of aviators continuing a successful and uneventful career with prolongation of the P-R interval to 0.25-0.27 second without symptoms or knowledge of their condition (Graybiel). Valuable personnel may thus be unnecessarily wasted if every case with a prolonged P-R interval is rejected from aircrew.

Left or right axis deviation should not entail rejection per se. Further investigation is indicated. Neither should slight elevation or depression of the S-T segments alone cause rejection. The whole electrocardiographic picture must be considered in relation to the history and the clinical findings.

T-wave inversion in Lead III is usually benign. Coronary heart disease is rare among aircrew candidates; consequently, if T-wave inversion is present in the other limb leads or in the chest lead, other causes must also be considered. Usually enough supporting evidence, either historical, clinical, the x-ray, or the electrocardiogram itself, can be found to substantiate a diagnosis. The subject of such T-wave inversion is usually unfit for aircrew.

The origin and type of premature beats are readily recognized in an electrocardiogram. As stated previously, premature beats occurring in runs, or arising from multiple foci, occurring at a heart rate above 110 per minute or increasing in number after exercise, entail rejection. If the T wave of the postextrasystolic contraction is inverted, organic heart disease is frequently present;[8b] such a candidate is unfit. Ectopic rhythms such as auricular flutter, which with 4: 1 block may easily simulate normal rhythm, and auricular fibrillation are unfit for aircrew. Nodal rhythm is better rejected.

In the early recognition of silent coronary heart disease during the third and fourth decades, routine electrocardiograms on aircrew personnel are an important diagnostic aid. Once definite evidence of myocardial impairment or conduction tissue defect is discovered, the subject should be grounded.

Neurovascular Instability.—Under the prevailing system of volunteer enlistment, most cases with labile pulses and blood pressures are due to nervous excitement lest they may not "make aircrew," the goal of their ambition. Many otherwise acceptable subjects have been rejected and, perhaps, still are being rejected because, with unstable

pulse and blood pressure readings, they have been unable to pass fixed numerical standards. Minor degrees of autonomic imbalance manifest in increased vasomotor and sudomotor activity are not associated with an increased "washout" rate in pilot training.

Marked autonomic imbalance calls for careful assessment of the candidate's temperament and emotional stability. An emotionally unstable person may learn to fly but does not make good combat aircrew material. Under the physical and psychic strain of war he is likely to break down. Borderline cases are frequent, and skilled psychiatric opinion is advised before they are accepted.

The syndrome called neurocirculatory asthenia has not been a problem in aircrew training in Canada. Several factors are responsible.

a. Rejection at recruiting level of any person with a history of the symptom complex.

b. Absence of strenuous physical exercise comparable to infantry training. (Routine gymnastics and athletics for "physical fitness" form part of aircrew training.)

c. Volunteer service automatically selects those with good motivation.

d. Careful appraisal of any case with vasomotor or autonomic instability before acceptance for training.

The descriptive term neurocirculatory asthenia for the well-known syndrome complex is used reservedly. If an accurate evaluation of the mixed symptomatology were made in each case, the diagnosis of anxiety state with cardiac neurosis or psychoneurosis with cardiovascular manifestations would be more frequently applied. The constitutionally inferior person, the long and lean individual with poor posture, flabby muscles, and pronounced vasomotor instability, in whom the psychic factor is probably the most amenable to treatment, is another type in whom the characteristic picture may be found. Others, however, with a stronger natural constitution, may break down under physical or nervous strain when they have been devitalized by infection, fatigue, or anxiety. Michael, writing on the aftermath of Pearl Harbor, compares men's minds to ships which sink when their buoyancy is destroyed.[6] The prognosis for the group better endowed by Nature is hopeful, for the cause can be remedied.

Fear and anxiety neurosis, hysteria, and reactive depression occur during training or under the strain of operational flights and are sometimes referred to the cardiologist because of cardiovascular symptoms. The latter may be prominent but are inconsequential. Treatment should be directed at the basic disturbance.

COMMENT

In aircrew selection, the cardiovascular examination naturally holds a prominent place. Perplexing problems arise in assessing the fitness for aircrew of borderline cases. The wide range of normal values is becoming better known and, with this, some "problems" have disappeared. Still, loss of valuable material results from too meticulous

adherence to fixed standards; some suggestions are made in this paper where judicious relaxation of standards might be made. The utilization of all desirable personnel becomes more important as the drain of war on man power continues. To some extent, the fortunes of war influence the demand for men and this secondarily affects the medical restrictions imposed on applicants for training. Poorer physical and constitutional types will become more frequent candidates. A serious attempt should persistently be made to exclude those persons with a definite neuropathic predisposition and the individuals poorly endowed by Nature referred to above. They rarely make satisfactory service personnel and never good combat aircrew, which, after all, is essentially what medical selection for aircrew fitness sets out to provide.

SUMMARY

1. Within the cardiovascular examination itself there are many perplexing problems in relation to selection and fitness for aircrew.

2. Normal cardiovascular function in a stable person without historical or clinical evidence of heart disease was the standard originally set for entry for aircrew training. The strain of war demands modification of the standards originally imposed.

3. Personal observations are made on the frequency of normal variations in heart size, shape, and action found in routine examinations on aircrew personnel. Some suggestions are made where relaxation of strict standards could make otherwise acceptable persons eligible for training, without undue hazard to themselves or to the Service. The place of electrocardiography and neurovascular instability in aircrew selection is briefly discussed.

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CARDIOVASCULAR EXPERIENCES IN AN ARMY GENERAL HOSPITAL

MAJOR RENO R. PORTER, M.C., ARMY OF THE UNITED STATES

THIS report is a review of the cases of cardiovascular disease seen in an Army general hospital. To such a hospital gravitate the problem cases, the unusual conditions, cases requiring prolonged or special treatment, and other cases for further observation and disposition. Since cardiovascular diseases, by and large, fall into one or another of these categories, it is logical that a large percentage of these cases turning up in the Army eventually find their way to a general hospital. A review of such cases should be of interest in showing not only the types of cases encountered but also the problem of cardiovascular diseases in the Army.

The material for this review consists of the cases admitted to the Lovell General Hospital, Fort Devens, Massachusetts, which is the Army general hospital serving the military installations in the New England states, upper New York state, and certain overseas bases. This hospital has been in operation for a little over two years and during this time has had approximately 10,000 admissions. Of this number, there were 440 cases of "organic" cardiovascular diseases and about an equal number of "functional" cardiovascular disorders. We have no information concerning the Army population from which these cases were drawn and hence can give no percentage incidence of these conditions in the Army. Further, it should be mentioned that, during the period covered by this report, the vast majority of the admissions to the hospital represented casualties of mobilization and training, few, if any, being related to actual combat.

Except for a few pertinent observations, no detailed analysis of all of the data is presented, as such a presentation would be beyond the scope of this paper, which is primarily a general survey of the problem. With this in mind, the various types of diseases will be taken up and brief mention made of any salient features.

ORGANIC CARDIOVASCULAR DISEASES

The cases of "organic" cardiovascular diseases are classified etiologically in Table I.

Rheumatic Fever (59 Cases).—These cases were observed either during the active phase of the disease or during convalescent care following the acute illness elsewhere. It was possible to give these patients the optimum of care because the duration and type of hospitalization was determined solely by the activity of the disease without concern for the financial or economic status of the patient. Twenty-five per cent

TABLE I

ORGANIC CARDIOVASCULAR DISEASES

Rheumatic fever	59
Rheumatic heart disease	90
Hypertension	88
Arteriosclerosis	109
Cardiovascular syphilis	3
Congenital heart disease	7
Dysfunction of rhythm or conduction	34
Miscellaneous cardiac diseases	15
Miscellaneous vascular diseases	35

of the cases showed evidences of residual valve deformities at the end of their illness, but it is quite possible that some of these cases had valvular lesions prior to the current attack of rheumatic fever. The disposition of these cases varied with the individual case. Many of them were placed on limited service for three to six months and then returned to full duty. Others were discharged from the Service, particularly if they gave a history of frequent attacks of rheumatic fever or had residual valvular damage. A few in this latter group were retained on limited service if they were particularly valuable in their jobs. In recent months limited service duty has been for the most part abolished, so that now we are discharging almost all of these men, retaining only a few who can be rehabilitated to full service within a short while.

Rheumatic Heart Disease (90 Cases).—These cases had been discovered during routine examinations or hospitalization after entrance into the Army. None of them had had any acute illness in the Army, which could be considered rheumatic fever in any form. In our opinion, all of these lesions were present prior to Army service and were unrecognized at the time of entrance examination; hence, they can be placed in the class of "preventable" cardiac casualties. However, they represent less than 1 per cent of the total hospital admissions, so it is a relatively small group in the total number of casualties. Under the conditions existing in many induction stations, it is not surprising that some lesions are overlooked and are subsequently discovered only during the leisure and quiet of a hospital or clinic. We feel that the "screening out" of valvular heart disease has been well accomplished during the present mobilization. Of particular interest in this group of patients were the observations that 40 per cent of the cases had no symptoms of heart disease, even during active military service, and that 60 per cent of the cases were discovered incidentally during routine examinations or while hospitalized for some other condition. Three cases had superimposed subacute bacterial endocarditis. Practically all of the cases in this group were disposed of by discharge from the Service.

Hypertension (88 Cases).—The evaluation of abnormal elevations of the blood pressure has presented quite a problem, not only in the rela-

tive number of cases involved, but also in regard to disposition. The Army has specific standards of blood pressure values, but the difficulties arise in judging the significance of any particular blood pressure determination. This may vary considerably in the same person, depending upon the circumstances of the examination, so it is largely a matter of opinion as to just which patients should be considered as having hypertension. Many individuals will show abnormal elevation of the blood pressure on initial examinations, but, subsequently, will have normal pressures following varying periods of normal activity, restricted activity, or complete bed rest. However, the more restriction required to produce lowering of the pressure to normal, the more abnormal becomes the individual's existence, under which circumstances the blood pressure values are of questionable significance. Since an arbitrary line must be drawn somewhere, it has been our policy to have those patients under observation for hypertension on an ambulatory status but resting in bed for one-half hour prior to determination of the blood pressure three times daily. If, under these circumstances, a patient had a persistent blood pressure above 150/90, he was considered to have hypertension. Those patients who had nonpersistent elevations of the blood pressure were classified as "vasomotor disturbance with tendency to hypertension," a group that will be taken up later under functional cardiovascular diseases. Of the 88 cases of hypertension, 19 patients had varying degrees of cardiac enlargement and were considered to have hypertensive heart disease. Most of these were mild to moderate in degree, with only a few in the stage of frank congestive heart failure. Four of the cases of hypertension were associated with chronic nephritis, one was associated with polycystic kidneys, and four were of the "malignant" variety. One of these latter cases came to post-mortem examination and was found to be on the basis of healed periarteritis nodosa, particularly marked in the kidneys.

Arteriosclerosis.—As might be anticipated, this condition was found, for the most part, in the older age group of commissioned and noncommissioned officers. It occurred as a primary diagnosis in 109 cases, 47 of which were considered to have generalized arteriosclerosis uncomplicated by heart disease. Some in this latter group presented symptoms referable specifically to the cerebral or peripheral circulation and others showed evidences of generalized deterioration, but, for the most part, the arteriosclerosis was not out of proportion to the patients' ages and was not incapacitating to any significant degree. There were 18 cases classified as having arteriosclerotic heart disease, as manifested by symptoms of cardiac disease (exclusive of chest pain) out of proportion to their ages. Twenty cases were considered to have true angina pectoris. One of these was of particular interest because he was only 24 years of age, gave a classical history of the disease, and had other findings consistent with hypercholesteremia. There were 24 cases of coronary occlusion with myocardial infarction, as evidenced by

classical histories and characteristic electrocardiographic findings. Three of these cases are noteworthy because their ages were 21, 24, and 30 years, respectively. The disposition of all of these cases was largely an individual problem. If the condition was considered to be service-connected and if the individual was particularly valuable in a specific sedentary position, he was retained in the Service. Otherwise, they were separated from the Service.

Cardiovascular Syphilis.—This was a relatively rare condition, occurring in only three cases. Two of these had simple, uncomplicated aortitis, and the third had aortic insufficiency with cardiac enlargement. The decrease in cardiovascular syphilis in general, due to more adequate treatment and the routine induction serology which identifies and separates the syphilitic person, probably explains to a large extent the relatively infrequent occurrence of this condition in the Army.

Congenital Heart Disease (7 Cases).—There were two cases of coarctation of the aorta, two cases of complete dextrocardia, and one each of patent ductus arteriosus, interventricular septal defect, and bicuspid aortic valve. The latter case had superimposed subacute bacterial endocarditis.

Dysfunctions of Rhythm or Conduction (34 Cases).—These occurred as incidental and isolated electrocardiographic findings in patients with otherwise normal hearts. There were thirteen cases having varying degrees of auriculoventricular or intraventricular block, two of the latter belonging to the so-called "Wolfe, Parkinson, White syndrome." Twelve cases had arrhythmias due to either auricular or ventricular premature beats. There were six cases of idiopathic auricular fibrillation, two cases of paroxysmal tachycardia, and one case of auricular flutter.

Miscellaneous Cardiac Diseases (15 Cases).—There were six cases of isolated pericarditis; two were purulent in type, two were tuberculous in origin, and two were of the so-called "idiopathic" variety. Cardiac enlargement of undetermined etiology was found in five cases, all of which showed significant enlargement of the heart on physical examination and by x-ray studies in young adults without hypertension and without other evidences of cardiovascular disease. There were three cases of traumatic heart disease, two involving foreign bodies in the heart, and one of myocardial contusion. There was one case of acute bacterial endocarditis secondary to a lobar pneumonia.

Miscellaneous Vascular Lesions (35 Cases).—There were twelve cases showing peculiar vasospastic changes in the fingers, which we placed in the category of Raynaud's phenomena. It occurred in individuals who previously had had no difficulty until they were stationed in cold climates. The involvement varied from a portion of one or two fingers to the entire hands, and the disturbance tended to subside on return to a more temperature climate. While the involvement varied between individuals, it was quite constant for each patient and could be reproduced by immersing the hands in ice-cold water. There were eleven cases of

venous thrombosis, ten of them in the nature of thrombophlebitis and one of them traumatic in origin. Five cases had so-called "causalgia" and three cases had thromboangiitis obliterans. There were four cases of arteriovenous fistula, two congenital, and two traumatic in etiology.

FUNCTIONAL CARDIOVASCULAR DISORDERS

Some mention should be made of the large group of cases classified as "functional" cardiovascular disorders. It consists of those individuals who were hospitalized or came under the observation of the cardiovascular consultants because of symptoms or signs suggestive of cardiovascular disease. In many cases, the symptoms were of sufficient degree to incapacitate the individual. After thorough studies, all were found to have no evidences of organic cardiovascular disease nor any disturbances in cardiac rhythm or conduction. The exact number of these cases is not tabulated, but their number approached that of the cases of "organic" heart disease. They presented a tremendous problem in diagnosis and disposition. Time does not permit an adequate presentation of this problem, however, and our data on it are not completed, so only a few salient points will be given.

Neurocirculatory Asthenia—Psychoneurosis.—These two conditions, which represent the vast majority of the functional disorders, are grouped together because there is, as yet, no clear separation of the various conditions classified under one or the other of these designations. The question as to how much is psychogenic and how much is physiologic in the etiology of these conditions, is still the subject of numerous discussions and extensive investigations. In our experiences, most of the cases designated as neurocirculatory asthenia presented definite psychoneurotic traits, usually of the anxiety type. In only 31 cases did we make the diagnosis of "classical" neurocirculatory asthenia on the basis of the association of the symptoms exclusively with effort. Even some of these had certain psychoneurotic tendencies and the diagnosis was not without question. By far the greater number had symptoms at rest as well as on exertion, and they usually occurred in attacks during certain "settings." A few cases of cardiac neurosis were encountered which we considered distinct from both neurocirculatory asthenia and psychoneurosis of the anxiety type. Regardless of the specific designation of these cases, practically all of them were incapable of performing any useful service in the Army and, therefore, were separated from the Service. Efforts to rehabilitate these men met with uniform failure. A rare case with postinfectious type of neurocirculatory asthenia was restored to full duty after a conditioning period.

Vasomotor Disturbance With Tendency to Hypertension.—This group consisted of those patients, 81 in number, under observation for hypertension, who did not show a persistent elevation of the blood pressure above the normal limits. It is the class of individuals sometimes designated as "prehypertensive." In the usual case, the blood pressure was

found elevated to abnormal levels during a routine examination but subsequently returned to normal levels after varying periods of hospitalization. Few had symptoms usually associated with hypertension, but many of them presented various complaints, usually psychogenic in character. In the majority of these cases the neuropsychiatric consultant made a diagnosis of psychoneurosis, more commonly of the anxiety type. Most of these patients were incapacitated for any useful service because of psychogenic symptoms, but a few, however, were returned to limited service in positions where there were no particular stresses or strains.

There were a few patients without symptoms who were hospitalized because of cardiac murmurs considered to be of organic origin, but which we interpreted as functional in nature. These were returned to duty after being given reassurance as to their cardiac status. There was also a small group of patients who had symptoms suggestive of heart disease which were found to be on the basis of extracardiovascular conditions, such as obesity, pulmonary disease, etc.

COMMENT

An interesting variety of cardiovascular diseases is seen in an Army general hospital. They represent only a small portion of hospital admissions, but the problems involved in these cases are numerous and stimulating. Unfortunately, most of the cases are not amenable to restoration to full service duty and the cardiovascular consultant is more concerned with the evaluation and disposition of cases than he is with actual therapeusis. Nevertheless, this function of identifying and separating the potential cardiovascular casualties is a very important one to the Army.

CARDIAC PROBLEMS IN A STATION HOSPITAL

Lt. Col. Morton G. Brown, M.C.
Fort Devens, Mass.

THE distribution of cardiac problems in the Army is different from that in civil life in that young people are predominant in the Service, and the examination at induction centers eliminates, for the most part, the group with organic heart disease.

During the course of a twelve-month period, there were only thirty-six soldiers who were discharged from the Army at the Station Hospital, Fort Devens, Massachusetts, because of organic heart disease. Twenty-three had rheumatic valvular damage; seven, congenital defects; three, paroxysmal arrhythmias; one, syphilitic aortic regurgitation; one, subacute bacterial endocarditis, and one, angina pectoris. In view of the fact that all selectees in New England come to the reception center at Fort Devens, this small number emphasizes the excellence of the examination in reference to the heart done at the induction stations.

Coronary and Hypertensive Heart Disease.—As a result of dealing with young people, the problem of coronary and hypertensive disease plays a minimal role. Although no exact figures are available, it is an impression that the incidence of degenerative disease, even in the older age group, is less than in civil life. This, too, may be due to the selection of personnel. It is to be noted, however, that these diseases occasionally do occur in the young. We had one soldier 19 years of age who developed a coronary thrombosis with myocardial infarct, and subsequently showed congestive heart failure and died. Similar incidents have been reported from other army installations. It must be emphasized that apparent good health and youth should not preclude the consideration of the degenerative diseases in the presence of a clinical picture.

Acute Rheumatic Fever.—The clinical picture and course of acute rheumatic fever in the Army are no different from that generally described. One is impressed, however, by the large number of antecedent sore throats, and by the fact that more than 50 per cent of the patients present themselves in the first attack. Patients with rheumatic fever are a special problem for the Army, as to both their care and their disposition.

The soldier is kept in bed until all clinical signs of activity have ceased, and the sedimentation rate has reached, or approached, normal. Then there follows a period of supervised graduated activity until the patient is able to stay up all day and participate in mild exercises.

Those soldiers who are admitted in an acute attack and show evidence of residual damage at the end of their convalescence are discharged from

the Service. The Surgeon General has not established a policy which requires the discharge of men who have an attack of rheumatic fever in the Army because they have a history of attacks of rheumatic fever in civil life. I believe, however, that they are poor risks, despite the evidence that they are not likely to develop organic valvular damage with their recurrent attacks.[1, 2]

The group of soldiers who show no heart disease at the end of convalescence from their first attack are given a one-month sick furlough, and brought back to the hospital for further examination before return to duty. The Surgeon General in a recent directive has indicated that individuals may be retained in the Army who have apparently fully recovered, but they should not be considered as qualified for full military duty until a period of six months has elapsed.[3]

Inasmuch as the final evaluation of the state of the valves must be delayed for several years after an attack of rheumatic fever, an arbitrary period of observation is designated to eliminate the greatest number who are likely to develop organic valvular damage. The procedure outlined, no doubt, returns to duty some soldiers who will subsequently develop organic valvular damage. It is felt, however, that the health of the individual is not jeopardized since he will be subject to constant medical supervision. It has been pointed out previously that 50 per cent of patients showed no evidence of heart disease following acute rheumatic fever.[4] As follow-up studies are not available as yet on the group who were discharged to duty, it is not possible to state whether this continues to hold.

Neurocirculatory Asthenia.—Dyspnea, palpitation, easy fatigue, and precordial pain without organic basis is a symptom complex familiar to all. In a twelve-month period there were over 300 soldiers with the syndrome at this hospital (nearly ten times as many as those with organic heart disease). There are, of course, all gradations of severity, from the soldier who has symptoms at rest, to the one who can perform light duties, from the soldier who complains almost immediately on arriving at camp, to the one who manages to carry out part or all of his basic training.

One usually finds that the symptoms date back many years. In this group only two or three soldiers developed symptoms for the first time after being in the Army. Most of these men have somatic complaints elsewhere in the body, but the symptoms referable to the heart completely overshadow these. Although some of the soldiers claim that they do not know what ails them, the majority will relate that physicians had told them at one time that there was something the matter with their hearts.

The psychiatric approach to this problem reveals the fact that we are dealing with unstable individuals who make a poor adjustment to civilian life. Since it is felt that these patients are psychoneurotic and are obviously constitutionally inferior, I am in complete accord

with Dr. Paul D. White who feels that they should never be admitted to the Army even if the condition is mild.[5] The major problem for the psychiatrist at the induction centers is to recognize the men with conscious motivation.

An attempt was made to return mild cases to duty or to adjust their duties to their capabilities. For the most part, however, these soldiers exerted a demoralizing effect on any unit to which they were attached. They could not do calisthenics, hike, or do laborious work. They reported to Sick Call frequently. In this way they interfered in almost every training program. Moreover, when a group of soldiers recognized that one member was apparently excused from some duties, those symptoms resulting in the excuse became just as contagious as the exanthemas.

Soldiers with this condition should be separated from military service unless they have special training to perform a sedentary job, and can do it without symptoms. The loss in man power resulting from such a program will be more than compensated for by the quality of work of the remaining soldiers.

SUMMARY

The picture that I have given of cardiac problems at the Station Hospital at Fort Devens is probably the same for all hospitals serving troops young in their Army career or in noncombatant branches. As the training program becomes more severe, most cardiacs (organic or functional) fall by the wayside.

The situation could be called ideal if we had only cases of rheumatic fever and degenerative diseases to report. The presence of the large number of soldiers with neurocirculatory asthenia is a challenge to the examining physicians at induction stations.

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HEART DISEASES AND DISORDERS AS CAUSES FOR EVACUATION FROM THE SOUTH PACIFIC COMBAT AREA

CAPTAIN HOWARD B. SPRAGUE, M.C., U.S.N.R., AND
LT. COMDR. SYLVESTER MCGINN, M.C., U.S.N.R.

A RECENT report of 900,000 rejections for military service shows cardiovascular diseases as third in importance (96,000), being surpassed only by dental defects (188,000) and defective eyes (123,000) as causes for refusal of enlistment. The purpose of the present study was to determine the adequacy of this screening, as shown by the appearance of cardiovascular disease as a cause for evacuating military and naval personnel from the combat area of the Solomon Islands and adjacent waters. The basis for the analysis is the experience of the hospital ship, U.S.S. ————, in transporting sick and wounded from this area from July 1, 1942 to July 1, 1943, and the experience of a Naval Base Hospital in New Zealand from Sept. 8, 1942, to Sept. 13, 1943.

In this year, 9,085 new patients or single readmissions (Army, Navy, and Marines) were admitted to this hospital ship, while there were 13,000 total admissions to the Base Hospital.* The senior author was not at that time attached to the ship but to the shore hospital in New Zealand to which the U.S.S. ---------- evacuated 993 of these patients. The records of the patients transported on the hospital ship have been consulted, and the information added from further observation on the ship has been critically reviewed by one of us (H.B.S.), from the standpoint of a cardiologist, while those in the Base Hospital have been analyzed by the other (S.M.).

As would be expected, a certain number of men who had become incapacitated, and in whom the cardiovascular system was erroneously incriminated, were evacuated from the forward areas without opportunity for adequate study, and the attempt has been made to analyze the data to arrive at the correct diagnosis. Such an attempt is not without danger of inaccuracy but it is believed that the results are approximately correct.

HOSPITAL SHIP EXPERIENCE

The original admission diagnoses to the ship are shown in Table I.

It is obvious that even if all of these patients had been suffering from cardiovascular disease, the percentage evacuated from this cause is very small; but the observations made while the patients were aboard the hos-

The opinions or assertions contained in this article are the private ones of the authors and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

*This figure from the Base Hospital is the total number of admissions and includes readmissions in each instance as if new patients. The actual number of individuals would be somewhat lower; this figure is not available at the moment.

TABLE I

VALVULAR DISEASE	DIAGNOSIS UNDETERMINED	NO.
Valvular heart disease	1	11
Myocarditis, rheumatic	1	1
Carditis, rheumatic	2	2
Endocarditis, acute		2
Endocarditis, chronic		1
Subacute bacterial endocarditis		1
		18
DEGENERATIVE HEART DISEASE		
Hypertension	1	20
Myocarditis, chronic	2	9
Angina pectoris	3	11
Thrombosis, coronary artery	2	7
Arteriosclerotic heart disease	1	1
Coronary heart disease		2
Arteriosclerosis, coronary		1
Cardiac asthma		1
		52
MISCELLANEOUS		
Effort syndrome	2	14
Tachycardia	2	12
Cardiac arrhythmia	1	4
Cardiac neurosis		2
Hypotension		1
		33
Total cardiovascular cases*		103
Percentage of total cases admitted		1.13

*The records of two other patients were not available. They are not included in the series.

pital ship resulted in modifications of these diagnosis as shown in Table II. Such changes in diagnosis could not always be made prior to evacuation from the ship to a shore base hospital, due to the short time the patients were aboard, and they represent the personal opinion of the senior author.

It is concluded that the reasonably well-proved incidence of cardiovascular defects causing admission to this hospital ship from the combat area of the Solomon Islands, and as far south as New Caledonia, is 0.6 per cent.

NAVAL BASE HOSPITAL EXPERIENCE

At U. S. Naval Base Hospital ————, in New Zealand (originally designated U. S. N. Mobile Hospital), patients were received from various hospital ships, transports, occasional combat ships, local marine and naval establishments, and from another base hospital in this country. Two important modifying factors are present: one is the higher incidence of recurrent malaria with readmissions from local marine establishments, and the other is the longer period of observation which was possible in the hospital as contrasted with the few days aboard the hos-

TABLE II

VALVULAR HEART DISEASE	CHANGES IN DIAGNOSIS	PROVED CASES
Valvular heart disease of all types but presumably of rheumatic origin. In no case were the findings typical. The heart was negative by x-ray in 3, and no x-ray was made in 1)		4
Other conditions originally diagnosed chronic endocarditis or valvular disease:		
Chronic bronchitis	1	
Bronchiectasis (?)	1	
Myalgia of chest wall	2	
Recurrent malaria	1	
Effort syndrome	1	
No cause for diagnosis discovered but no evidence of heart disease	3	
	9	
Acute endocarditis (proved by autopsy)		1
Acute endocarditis disproved	1	
Subacute bacterial endocarditis disproved	1	
DEGENERATIVE CARDIOVASCULAR DISEASE		
Arterial hypertension		6
Other conditions originally diagnosed hypertension:		
Fatigue	2	
Anxiety neurosis	3	
Recurrent malaria	1	
Arthritis of spine	1	
Chronic nephritis	1	
No hypertension or other disease	2	
	10	
Coronary heart disease		5
Arteriosclerotic heart disease		1
Arteriosclerotic heart disease originally diagnosed but no confirmatory evidence. Symptoms considered due to heat exhaustion and salt loss	1	
Coronary thrombosis		4
Angina pectoris		7
Angina pectoris originally diagnosed but not characteristic and symptoms considered due to:	-	
Anxiety neurosis	3	
Neurocirculatory asthenia	1	
Probable arthritis of spine	1	
Malaria	1	
	6	
Cardiac asthma—negative heart examination and considered allergic in type	1	
Myocarditis—in only one instance was the diagnosis of heart disease confirmed and the proper diagnosis of coronary heart disease, arteriosclerotic, is preferable	-	1
Other conditions originally diagnosed myocarditis were:		
Varicose veins and extrasystoles	1	
Varicose veins and respiratory infection	1	
Obesity	2	
Malaria	1	
Vague chest pain of atypical nature	2	
Auricular fibrillation from severe combat injury to chest	1	
	8	

TABLE II—CONT'D

FUNCTIONAL CARDIAC DISORDERS	CHANGES IN DIAGNOSIS	PROVED CASES
Effort syndrome or neurocirculatory asthenia		13
Other conditions originally diagnosed effort syndrome:		
Fatigue combat	2	
Fatigue combat and malaria	1	
Probable paroxysmal tachycardia	1	
	4	
Tachycardia, simple—but found to be due to:		
Anxiety neurosis	1	
Neurocirculatory asthenia	1	
Fatigue and recurrent malaria	4	
	6	
Paroxysmal tachycardia (none proved but with characteristic history)		5
Extrasystoles		2
Auricular fibrillation (probable)		1
Auricular fibrillation (proved by ECG)		1
Hypotension (not confirmed on the ship but associated with recurrent malaria)	1	
SUMMARY (PROVED CASES PLUS FOUR CORRECTED DIAGNOSES)		
Valvular disease and acute endocarditis		5
Functional cardiac disorders:		
Effort syndrome and neurocirculatory asthenia		16
Paroxysmal tachycardia		6
Premature beats (extrasystoles)		2
Auricular fibrillation		2
Degenerative cardiovascular disease:		
Arterial hypertension		6
Coronary heart disease		6
Arteriosclerotic heart disease (questionable)		1
Coronary thrombosis		4
Angina pectoris		7
		55
Patients admitted with established diagnoses of, or suspected of having, cardiovascular disease but considered not to have these conditions*		48
Percentage of total evacuated patients probably attributable to cardiovascular disease		0.6

*Discrepancies between figures in this group and those in Table I are due to changes of diagnosis during observation aboard ship but do not alter the percentage of patients finally determined as having true cardiovascular disorder.

pital ship. It will be seen, however, that the independent study of the two authors confirms the approximate incidence of cardiovascular disease in the South Pacific area.

The discharge diagnoses from the Base Hospital are shown in Table III.

Rheumatic Fever.—A comparison of the incidence of rheumatic fever aboard the hospital ship and at the Base Hospital shows 22 cases on the former (0.24 per cent), and 14 cases at the latter activity (0.1 per cent). It is considered that the former figure is too high and only an approximation, since prolonged observation is often necessary to establish this diagnosis, and study with the electrocardiograph and sedimentation rate

TABLE III

INFECTIONS AND CONGENITAL HEART DISEASE		
Valvular heart disease		7
Mitral insufficiency	3	
Mitral stenosis and insufficiency	1	
Aortic stenosis	1	
Aortic and mitral stenosis and insufficiency	2	
Myocarditis—chronic rheumatic		1
Acute bacterial endocarditis		1
Congenital heart disease—interauricular septal defect		1
DEGENERATIVE HEART DISEASE		
Arterial hypertension		25
Thrombosis of coronary artery		3
Coronary heart disease		5
Angina pectoris		1
FUNCTIONAL CARDIAC DISORDERS		
Effort syndrome		23
Tachycardia		12
Paroxysmal auricular tachycardia		4
Auricular fibrillation		3
Premature beats (extrasystoles)		2
Total		88
Percentage of cardiovascular cases in 13,000 admissions		0.67

is difficult, if not impossible, at sea. Such studies were undertaken at the Base Hospital and showed a low incidence of rheumatic fever, but confirmed other observations of the occurrence of rheumatic fever in the tropics. All attacks in patients on the ship appeared in the tropics, as did most of those in the Base Hospital, although some appeared in personnel stationed in New Zealand.

It is of interest that the admission rate of adults with rheumatic fever to the Wellington Public Hospital, Wellington, New Zealand, in the years 1939 to 1942 is 0.3 per cent in spite of a wet, windy, cold climate. The admission rate for children is 0.9 per cent.*

DISCUSSION

This analysis emphasizes a few practical points. Though it may mention certain diagnostic errors, it must be considered in no sense a criticism of the diagnostic efforts of the combat medical officers. The authors are fully aware of the difficulties of such duty, and of the necessity for the use of the term "diagnosis undetermined" in many instances. However, when under the stress of battle or the burden of tropical exposure and malaria, the heart is apt to be blamed for fatigue and a multitude of chest complaints of which it is not culpable. The major reason for avoiding unproved cardiac diagnoses is to prevent

*Figures secured through the courtesy of Dr. J. O. Mercer and Miss Ernestine Winstone, Department of Pathology, Wellington Hospital.

accentuating cardiac neurosis and heart consciousness which are so prominent in rehabilitation problems.

Valvular heart disease has been rare in our experience, eleven cases in over 22,000 observations. Surely the elimination of men with this condition has been satisfactorily accomplished at enlistment, induction, and training centers. The problem of screening out those with a past history of rheumatic fever is far more difficult, but the recrudescence of the disease, under conditions of exposure, even in the tropics, makes such an attempt advisable, as suggested by Master.* Certainly men developing rheumatic fever in the Service should not be retained except under unusual circumstances. The increasing importance of it in training areas has been recently pointed out by Dr. T. Duckett Jones.

Greater caution should perhaps be employed in the elimination for overseas duty of men in the older age periods. Most cases of *persistent hypertension* are found in the older men. On the hospital ship, five out of eight were over 35 years of age, and of these three were chief petty officers and one a warrant officer in their forties and fifties. The emotional hypertension of combat conditions in younger individuals usually responds rapidly to rest and freedom from responsibility in a noncombat area. When it does not, and the physical and laboratory findings are normal, a deeper anxiety state must be suspected, and the man must be evacuated home as he will probably not be efficient in the combat area again.

The age of patients on the hospital ship, with the diagnosis *coronary heart disease* and *angina pectoris* ranged from 40 to 53 years. The ages of those with *coronary thrombosis* were 37, 42, 48, and 49 years. Angina tended to be overdiagnosed in various fatigue and anxiety states in young individuals and the final figure of those on the ship may even be too high.

The inaccurate portmanteau diagnosis *myocarditis* was overworked. It should not be used to mean coronary heart disease nor as a catchall for various sorts of vague chest and respiratory symptoms; but, if used at all, it should refer to an inflammation of the heart muscle as seen in rheumatic fever or diphtheria. It is usually a diagnosis which obscures rather than enlightens.

Effort Syndrome and Neurocirculatory Asthenia are less frequent than in World War I. Sufferers from these conditions appear to be better eliminated early during recruiting or training. Gastrointestinal disorder appears to be the organ neurosis of World War II.

Sinus *tachycardia* usually means anxiety, fatigue, heat exhaustion, anemia, or malaria. No case of thyrotoxicosis has been seen. In certain instances, however, sinus tachycardia has persisted without adequate explanation. Such patients, like those with persistent unexplained hypertension, are no longer valuable in a combat area.

*Comdr. Arthur M. Master, M.C., U.S.N.R., Rheumatic Fever in the Navy, U. S. Nav. M. Bull. 41: 1019, 1943.

SUMMARY AND CONCLUSIONS

During the period July 1, 1942, to July 1, 1943, 9,085 patients (Army, Navy, and Marines) were admitted to the hospital ship U.S.S. _____, acting as an evacuation ship for casualties from the Solomon Islands, New Hebrides, and New Caledonia. In this year, only 55 patients were found to be suffering from valvular heart disease, degenerative heart disease, or functional disorders of the heart. This is an incidence of 0.6 per cent. Forty-eight others, in whom cardiovascular disease was suspected, were found to have no evidence of such disorders but were suffering from other conditions, usually anxiety, fatigue, and malaria, with indefinite physical signs and symptoms. Twenty-two patients with rheumatic fever were evacuated during this period (0.24 per cent).

During the same year, 13,000 admissions (including all readmissions) were made to U.S. Naval Mobile Hospital _____ (later U.S. Naval Base Hospital _____), in New Zealand. A similar study shows that 88 patients were suffering from organic, or disabling functional, cardiac disorders—an incidence of 0.67 per cent. Rheumatic fever occurred in 0.1 per cent of the total.

Typical effort syndrome and neurocirculatory asthenia, while still important, appear to be less common than in World War I. Part of this is due to these syndromes being absorbed into neuropsychiatric diagnoses without emphasis on the circulatory system. However, even in such instances, we have been impressed with the relative infrequency of the classical picture of cardiovascular instability as the presenting and disabling symptom complex.

This survey indicates that elimination of men with heart ailments is being satisfactorily accomplished in enlistment, recruiting, induction, and training areas.* Somewhat greater caution should be observed in assessing the cardiovascular status of older men in the determination of fitness for overseas and combat duty. The unsubstantiated diagnosis of cardiovascular disease in naval and military personnel on combat duty, and especially in fatigue states, should be avoided to prevent the development of cardiac neurosis and invalidism.

*It should be noted that the figures in this paper are based largely on an experience with carefully selected, volunteer troops, preponderantly marine and naval personnel, in whom physical defects should be minimal.

SOME PRACTICAL ASPECTS OF THE RHEUMATIC FEVER PROBLEM WHICH HAVE AN IMPORTANT BEARING IN MILITARY MEDICINE

BENEDICT F. MASSELL, M.D., AND T. DUCKETT JONES, M.D.
BOSTON, MASS.

GENERAL interest in rheumatic fever in the past few years has developed in proportion to the increased practical knowledge of the disease. However, for many years, we have lagged sadly in the development of programs for the care of rheumatic fever patients and in having rheumatic fever accepted as a public health problem. Physicians in England have been far more active than we in developing programs, such as providing beds for the treatment of these patients at public expense, making rheumatic fever a reportable disease, etc. Impetus in this country has developed largely as the result of small programs in a few states, instituted by the Children's Bureau of the United States Department of Labor. These carefully worked out plans, along with the study and care programs conducted by private agencies in a few large cities, represent pioneer work. Limitation of funds and of availability of trained medical, social service, and nursing personnel are distinct deterrents at present to the rational extension of these programs. As the medical profession becomes more aware of the various features of the rheumatic fever problem, it would seem almost certain that they will insist upon broadening the scope of some of the present studies and programs by both private and public agencies.

At present, the country is in an "all out" war, with millions of men dislocated from their usual vocations and mode of living. For military purposes, it is essential that these men go through a herding experience quite unlike that experienced by the usual adult in time of peace. It is hence not surprising that epidemic infectious diseases occur. Variations in the presence and distribution of pathogens, population susceptibility, exposure, crowding, and many other factors influence considerably the disease patterns resulting in different groups of service men.

In addition to the large number of nonmedical personnel dislocated from civilian life by war, the medical profession has been proportionately called into service. Many physicians have been obliged to become proficient in the care and prevention of diseases far different from those encountered in their former medical experience. Many physicians who have had but little practical contact with the disease are now caring for patients with rheumatic fever and rheumatic heart dis-

From the House of the Good Samaritan, Boston, Mass.

ease. Often, the experience of these physicians has been limited to that which they gained as students or interns. This experience usually was restricted to the care of the acute rheumatic fever case and the evaluation of heart murmurs. Opportunity to observe these patients over long periods of time and to study the varying influences affecting the outcome of the individual patient has been afforded only a limited number of workers.

Having spent, with a group of active collaborators, some years studying various aspects of the rheumatic fever problem, we think it advisable to present an attitudinal review which may help to define the problem in the minds of physicians confronted with the care and disposition of patients with rheumatic fever. No attempt will be made to make this summary definitive or bibliographic. The same fundamental features hold, regardless of whether the Armed Forces or civilians are concerned, although the former raises many additional problems of a serious nature. No new concept is to be presented. The details and references to substantiate nearly all statements can be found in Paul's "Epidemiology of Rheumatic Fever (1943)," prepared and distributed at the request of the American Heart Association, and published through the cooperation of the Metropolitan Life Insurance Company. Although many questions remain to be answered, various investigations, at present being carried out by both military and civilian personnel, will doubtless add much to our basic knowledge, especially in the field of prevention.

THE ETIOLOGY OF RHEUMATIC FEVER

Perhaps no single statement concerning rheumatic fever would receive such universal medical agreement as one to the effect that the cause of the disease is unknown. While it is essential to state this early, and, further, to indicate that much basic work remains to be performed in this field, our knowledge of the natural history of rheumatic fever is not inconsiderable. We need not wait for further knowledge in order to develop programs of care and prevention. Dr. Homer F. Swift, long a student of rheumatic fever, has repeatedly stressed this, and we feel that investigators such as Coburn, Wilson, Kuttner, and others would agree, although each might stress various features, dependent upon their own particular experience and beliefs.

To review all of the suggested theories as to etiology would not seem relevant. Recently, there have appeared two suggestions concerning etiology. One theory reiterates the allergic hypotheses without any new data. The second theory is based on the observation that, in the rat, severe overdosage with desoxycorticosterone acetate produces lesions similar to those seen in periarteritis nodosa, malignant hypertension, and rheumatic fever. It is suggested that infections or exposure result in an abnormal (probably excessive) adaptive response of the adrenal

cortex, and, hence, rheumatic fever may be partly a disease of adaptation. These ideas need further study, interpretation, and correlation with known facts.

All observers agree to the high familial incidence of rheumatic fever, and increasing evidence points to an hereditary susceptibility.

The relationship between group A, beta-hemolytic streptococcal respiratory infections and rheumatic fever is well established, but many features concerning this relationship need clarification. For example, the antigen-antibody reaction, variations in types of hemolytic streptococci, and factors possibly influencing pathogenicity and epidemicity, need further study. Of primary importance would be the experimental reproduction of the disease or its counterpart, in an experimental animal. Some of these features are receiving attention now, while others must await a return to more leisurely study in a postwar world. Despite the need for these studies, present known facts about rheumatic fever are of practical value, and these will be stressed. It is believed that further knowledge will serve to clarify present accepted observations, and hence explain and extend rather than disprove them.

RHEUMATIC FEVER AS AN EPIDEMIC DISEASE

Epidemiology in recent years has become broadened by general usage. The medical and lay public apparently have preferred to persist in defining as epidemic disease only those great scourges representing an highly virulent agent producing great volumes of disease among highly susceptible peoples. The influenza epidemic of World War I is an example par excellence. The communicable diseases of childhood are also accepted. Only a limited number of workers, however, speak of the epidemiological pattern of noninfectious diseases, such as pellagra, and such a condition as mottled enamel. Scarlet fever is not only considered an epidemic disease, but too frequently as the only serious phase of the hemolytic streptococcus problem. This is reflected in the laws governing quarantine of scarlet fever cases, while infections without scarlatinal rash, even though caused by the same type of group A beta-hemolytic streptococcus are not restricted and often not even segregated. It is slight wonder that rheumatic fever, a disease which follows closely the epidemiological pattern of hemolytic streptococcal infections, is not considered an epidemic disease. Few physicians think of an epidemiological pattern in connection with this disease, save in relation to poor housing, crowding, and low economic level.

Ever since World War I, and especially in the past twelve years, numerous reports have stressed the association between hemolytic streptococcal tonsillitis and pharyngitis and the subsequent development of rheumatic fever. Coburn, more than any worker in this country, has emphasized this relationship. The relationship of rheu-

matic fever to hemolytic streptococcal respiratory infections has been reported by many English workers. Many hemolytic streptococcus epidemics have been recorded in rheumatic fever institutions and convalescent homes, with as many as 50 per cent of these having the epidemic infection developing a recurrence or recrudescence of rheumatic fever within two to three weeks. We may ultimately learn why these percentages vary with each epidemic, but one must accept that some relationship does exist. The grouping of hemolytic streptococci by Lancefield, and the later typing of group A strains by Griffith and by Lancefield have offered a new epidemiological tool with which to study the problem. The reports of Kuttner, Coburn, and others, as well as unpublished data from the House of the Good Samaritan are all in essential agreement. In a population where all are known to be rheumatic fever susceptible (by the presence of low-grade rheumatic fever or recent recovery from rheumatic fever), infections with certain types of hemolytic streptococci are associated with a varying number of recurrences of the disease. The strains causing trouble are usually epidemic in behavior and usually spread rapidly. The types of group A hemolytic streptococci may vary from year to year. It has been our experience that approximately one-third of the rheumatic fever recurrences are not preceded by a clinical hemolytic streptococcal infection, but careful and frequent throat cultures usually indicate that there has been a previous change in the type of hemolytic streptococcus in the throat, or a change from a negative to a positive throat culture.

To one who has not yet accepted the possibility that hemolytic streptococcal infections and/or some peculiarity in the immune reaction to such infections, is the entire mechanism in the causation of rheumatic fever, the close clinical, bacteriological, and immunological (antistreptolysin response) correlation between hemolytic streptococcal infections and rheumatic fever has consistently been viewed with skepticism. However, it seems reasonably certain to us that, despite the need of further knowledge, the importance of this association cannot be denied or dismissed.

It is much easier to demonstrate an association between hemolytic streptococcal infections and rheumatic fever, than to disprove it. Since instituting protective measures against the spread of hemolytic streptococcal infections in a rheumatic fever hospital, our rheumatic fever disease patterns have altered. In our experience, fatalities caused by rheumatic fever have been strikingly associated with increased severity of the disease following an hemolytic streptococcal infection. It has not been unusual to see fulminant, fatal rheumatic fever follow a hemolytic streptococcal infection, despite a good recent recovery from rheumatic fever with only minimal residual heart disease. Protection from hemolytic streptococcal infections has resulted in a disappearance of such catastrophies.

During a period of four years, we have observed several instances of increased cardiac failure without any definite evidence of preceding hemolytic streptococcal infection. Although such increase in failure is usually due to an associated increase in rheumatic fever activity, there was no other evidence of this in these cases. We have also observed the development of chorea in patients who had apparently recovered from rheumatic fever and who showed no evidence of antecedent hemolytic streptococcal infection. All of these apparent rheumatic fever recurrences occurred more or less simultaneously during a short period of three to four weeks. This information is included merely to indicate that all problems are not answered. With these exceptions, it has been our experience that, provided the early stages of rheumatic fever do not prove fatal, our patients have recovered after varying periods of time and with varying degrees of residual heart damage, unless hemolytic streptococcal infection has intervened. Hence, in our experience, rheumatic fever following hemolytic streptococcal infection is the major problem.

From a study of the literature, it seems likely that most initial attacks of rheumatic fever are closely associated with hemolytic streptococcal infections. Further, once an individual has had definite rheumatic fever, the vast majority will do well unless an hemolytic streptococcal infection occurs. The above observations are based on clear-cut diagnoses of rheumatic fever. Many individuals present the problem of rheumatic heart disease, even with failure, in adult life, and deny earlier rheumatic fever. In our experience, those patients with insidiously developed rheumatic heart disease (usually with mitral stenosis), from families who know the patterns of rheumatic fever because of disease among other members, have but little, if any, cardiac enlargement. These patients have universally done well unless rheumatic fever intervenes. Appreciable degrees of cardiac hypertrophy have been found only as the result of recognizable rheumatic fever. This is an interesting group of patients from which we may learn much, but it has consistently been evident to our group of workers that the seriously disabled rheumatic heart disease patient, if carefully studied, is found to have, or to have had, active rheumatic fever, usually at a clinically recognized level.

Recent English reports of studies on military personnel, and reports from military sources beginning to appear in this country, stress the fact that in the Armed Forces the rheumatic fever pattern is closely associated with the hemolytic streptococcal problem. While other factors, such as exposure, dampness, and chilling, may play a role, no report has failed to express the coexistence of throat infections, such as tonsillitis or pharyngitis, and even scarlet fever. While clinical diagnoses are not entirely reliable with regard to the etiological classification of respiratory infections, the presence of scarlet fever can be

taken to indicate that hemolytic streptococcal infections are present. Wherever there has been corroboration of clinical diagnoses of respiratory tract infections by bacteriologic examination, it has been found that the hemolytic streptococcus is present and apparently pathogenic when rheumatic fever begins to appear. Grouping and typing of these organisms throws additional light on the problem. Epidemic types or those pathogens which spread easily are usually found to be the troublemakers, despite the presence of a number and variety of types, of seemingly low pathogenicity in the same population. The carrier rates may vary considerably from season to season, even without any appreciable volume of streptococcal illness. However, when a given type of streptococcus begins to cause illness, this type will increase in the general exposed population, and the resultant illness pattern will be determined, at least to a large extent in an intimately exposed population, by the pathogenicity of the organism and the susceptibility of those exposed. From the available reports, it seems obvious that rheumatic fever occurs in variable degrees in the majority of, but not in all, hemolytic streptococcus epidemics. We do not yet know the influence of the streptococcus types, and other streptococcal biologic features, on the development of rheumatic fever, but it does seem apparent that rheumatic fever, in a population of unknown rheumatic fever susceptibility, occurs in direct relation to the volume of streptococcal illness. The rates will doubtless vary in different parts of the United States and the world, and there are doubtless many unknown factors affecting these rate variations. For instance, reports of rheumatic fever during streptococcal infections among young British naval personnel are the highest rates yet recorded. In addition to the volume of hemolytic streptococcal illness, other factors which may possibly influence the occurrence of rheumatic fever are: the evidence of a previous rheumatic fever history (this will be discussed in more detail further on), unknown host features, associated or previous virus invasion, and variations in the biology of hemolytic streptococci.

In military personnel, just as in the studies on known rheumatic fever populations, there is a consistent association between rheumatic fever and previous infection of the respiratory tract with the hemolytic streptococcus. This correlation holds from clinical, bacteriological, and immunological (antistreptolysin response) points of view. A high percentage of these patients give a definite history of sore throats (often with hemolytic streptococci isolated from the throat) ten to twenty-one days before, but in some this is absent, and only the antistreptolysin response curve gives a clue to the previous infection. This closely parallels the pattern in known rheumatic fever populations, and indicates that nonclinical, but definite invasive streptococcal infections occur. This has long been recognized from studies on streptococcal epidemics in well children.

Since the clinical diagnoses of respiratory tract infections are inaccurate without laboratory confirmation, the basis of any rheumatic fever program should be bacteriologic. Careful bacteriologic study of respiratory infections from any given epidemiological group should give the clue to the illness pattern developing, and offers the best hope of any prevention program. Thus, in order to anticipate the development of a streptococcal disease problem in any military establishment, it is first necessary to divide the population into epidemiological units, each of which is composed of individuals living together and having the same exposure periods. An accurate and continuous record must be kept of all clinical respiratory infections. Finally, the percentage of throat cultures that are positive for hemolytic streptococci must be determined on adequate samples of both the clinically ill and well individuals, composing each of these separate epidemiological units. Grouping and typing of all positive cultures will provide additional information of value.

To a medical ward officer receiving rheumatic fever patients for care from a wide variety of groups in his station or even different stations, the problem must indeed be confusing. Only when one realizes that, for each of these patients, there have previously existed many hemolytic streptococcal infections, can one begin to focus at the point where this patient's problem could have been attacked.

SUSCEPTIBILITY TO RHEUMATIC FEVER

There can be little doubt but that the familial incidence of rheumatic fever is high, and most reports indicate that multiple cases of rheumatic fever in a family are as frequent as found in the case of tuberculosis. The recent work of Wilson, Taussig, and their collaborators has strengthened the available data relative to hereditary susceptibility. While much needs to be learned in this field, the data which are accumulating strongly indicate the importance of a probable hereditary susceptibility. These data are doubtless important, but do not obviate the importance of a variety of other features in relation to the initial or repetitive development of rheumatic fever.

There can be no doubt but that one attack of rheumatic fever renders an individual susceptible to subsequent attacks. As indicated previously, many investigators, among them ourselves, feel that there is an association between these initial as well as repetitive attacks and infections with the hemolytic streptococcus.

No adequate data are available as to the number of susceptibles in the general population. Should such data become available, there would doubtless be considerable variations in a country with such marked climatic differences as the United States. This is suggested by present available information indicating a considerable sectional difference in incidence of rheumatic fever and heart disease. In fact it seems

reasonable to speak of high and low incidence areas, despite a lack of accurate incidence studies and knowledge of the many factors which might be responsible for such variations. It seems reasonable, as an estimate, that perhaps 2 per cent of our young adult population may prove to be susceptible to rheumatic fever as indicated by a definite history of the disease.

Reports already appearing in the medical literature indicate that there may be considerable variation with regard to the frequency of an history of previous rheumatic fever among those men developing the disease in military service. Some of these reports indicate a previous history in as high as 50 per cent of the rheumatic fever patients.

It becomes obvious from a practical point of view that the rejection of such men with a previous history would decrease the problem of rheumatic fever in the Armed Forces. Other practical points, however, must be considered and determined by military authorities. The mere administrative problems inherent in verifying any disease history in as many as 2 per cent of the applicants for military service are tremendous. When one considers that those anxious to perform military service could easily deny previous rheumatic fever, and that malingering by those desiring to escape military service may be common, the inherent practical problem becomes enormous. Furthermore, the rejection of susceptibles on a basis of history, if practical, would at best eliminate only one-third to one-half of the rheumatic fever cases in the Armed Services. The ultimate decision would seem rationally to be based on the administrative difficulties inherent in rejection of such applicants and the practicability of the development of preventive programs. However, opinions will doubtless vary greatly. It seems logical that the individual of unknown susceptibility deserves protection against the development of rheumatic fever just as much as those known to be susceptible by verified history. In consideration of the need for man power and the possible development of prevention programs (to be discussed later), it is suggested that we accept the responsibility of attempting to prevent hemolytic streptococcus epidemics in areas of high rheumatic fever incidence regardless of whether history susceptibles be accepted for service or not.

RHEUMATIC FEVER PREVENTION PROGRAMS

There are many possibilities relative to the development of such programs, and much is to be learned from a variety of organized attacks upon the problem. Should it be possible from an administrative point of view to direct the location of known susceptibles or of those developing rheumatic fever in the Service to low incidence areas, some preventive or prophylactic results might be expected. This is clearly an important administrative problem for the Armed Services.

Since rheumatic fever is outstandingly prevalent during hemolytic streptococcus epidemics, one naturally turns to the prophylactic use of

the sulfonamide drugs as being perhaps the most important feature of any program. There seems to be general agreement that once rheumatic fever has begun, the sulfonamides are ineffective (at least sulfanilamide and sulfapyridine) and may be harmful. There also seems to be general agreement that once a hemolytic streptococcal infection has begun, subsequent rheumatic fever cannot be avoided by the use of these drugs. It has been suggested that sulfonamides given after the onset of hemolytic streptococcal infection may even increase the possibility of development of rheumatic fever, although no substantiating data have been presented.

A number of reports have appeared in the last two or three years indicating that sulfanilamide given in small prophylactic doses to patients with previous rheumatic fever will prevent the development of hemolytic streptococcus infections and hence recurrent rheumatic fever. There seems no dissenting voice to this, but as yet no reports have reached the literature relative to the effectiveness of the less toxic sulfonamides. It has been indicated that a small percentage of individuals are unable to take such prophylactic agents because of sensitivity, and there are yet many features to be worked out. For instance, we do not yet know what the long-time administration of these drugs will do with regard to the development of sensitivity. Neither do we know whether drug-resistant strains of hemolytic streptococci will be developed as a result of such programs, or the effect on the rheumatic fever patient of infection with such drug-resistant strains.

Numerous reports are available relative to the effectiveness of sulfonamides in the control of the meningococcus problem. Cases may be abruptly terminated and carrier rates lowered. There are also reports indicating that the spread of streptococcal infections may be curtailed by the use of chemotherapeutic agents. Less is known concerning the effect on pathogenicity and the carrier state of streptococcal as compared to meningococcal infections. There seems, however, but little doubt that it is possible to affect the epidemic streptococcal pattern by the use of these agents.

Many features warrant careful study. The choice of the particular agent is not yet determined, nor the dosage, nor the exact method of administration. The comparative value of a small daily dosage over a long period of time as opposed to larger amounts of the drug given over a short period is not yet determined.

In view of the considerable variations in the spread of hemolytic streptococcus within different epidemiological units, one should be careful to avoid wholesale administration of such agents as the sulfonamides. It should also be pointed out that a false sense of security may be developed by confusing seasonal, annual, and unit streptococcal infection variations for drug effects.

Because of these possible misinterpretations of results, and because of the possible dangers of developing sulfonamide sensitivity and drug-fast strains, one should be reticent in too readily accepting the wholesale and uncontrolled administration of these drugs.

In recent years, interest in the possible value of salicylates for rheumatic fever has reawakened. Several reports suggest that the protracted daily administration of salicylates starting at the time of a hemolytic streptococcal respiratory infection may in some way greatly decrease the probability of developing subsequent rheumatic fever. This is in keeping with the recent suggestion that the intravenous administration of large amounts of salicylate (resulting in a high continuous salicylate plasma level) may, if begun early in the course of the disease, advantageously affect the outcome of rheumatic fever. It has been further suggested that the daily administration of egg yolk may result in the curtailment of the development of rheumatic fever recurrences. These are mentioned as features requiring further study and analysis.

Control measures other than the use of drugs also need careful evaluation. There can be little doubt that the segregation of hemolytic streptococcal infections may alter the pattern of disease in any given population. In the past, scarlet fever patients have been the only ones given appreciable attention. Scarlet fever comprises only a very small and varying proportion of all hemolytic streptococcal respiratory infections. Furthermore, clinical diagnoses alone are a poor index of hemolytic streptococcal illness. Therefore, if segregation is to be done in an advantageous way, it is necessary to do careful bacteriologic studies on all patients with respiratory disease. In addition to determining which patients have positive hemolytic streptococcus cultures, it is of value to group and type the isolated organisms in order to identify the pathogenic strains.

Literature reports suggest that, on an open scarlet fever ward, an individual patient maintains his infectious type for eight to ten days, thereafter frequently becoming a carrier of other types of streptococci to which he is exposed. Nevertheless, we do not know how long hemolytic streptococcal respiratory disease cases should be segregated. In order to answer this question intelligently it will be necessary to know whether individuals developing a carrier state without becoming clinically ill are infectious and just how long strains carried in the throats of recovered clinical cases remain virulent. It will also be necessary to learn more about the effect of sulfonamide therapy on the duration of the carrier state and on the virulence and spreading tendencies of hemolytic streptococci.

The nature of the living quarters in a military establishment may influence the spread of respiratory disease. It seems likely that exposure during sleeping hours is particularly important. There is evidence

which suggests that the volume of disease is influenced more by the number of individuals sleeping in a given room than by the area of floor space or the number of cubic feet of air space allotted to each man.

Other possible hemolytic streptococcus control measures which need further investigation are ultraviolet radiation and the use of aerosols.

To reiterate, the prevention of rheumatic fever, within the limits of our present knowledge, depends apparently upon the successful prevention of hemolytic streptococcal infections. In any given group or unit, the key to the development of such a problem rests with the careful bacteriologic study of individuals developing respiratory infections. Careful study may reveal the presence of an increasing hemolytic streptococcal disease rate long before the peak is reached, and so indicate the need of instituting preventive measures. It is hoped that in the near future we will have sufficient additional knowledge so that we will know what measures will safely prevent a maximal amount of illness, with a minimal use of chemotherapeutic agents and a minimal disruption of routine military programs.

PSYCHOLOGICAL FACTORS

One cannot help but be impressed with the inherent opportunities for the development of psychological difficulties in those individuals with rheumatic fever and its attendant rheumatic heart disease. Neurocirculatory asthenia is found to be common in adults with rheumatic heart disease. It has often impressed us that the old adage, "A little learning is a dangerous thing," is most appropriate. This is small wonder when one considers the amount of teaching done in the presence of rheumatic fever patients and the general inclination of physicians to stress the heart disease factors above all else.

Only those rheumatic fever subjects developing serious degrees of heart disease become actual cardiovascular cripples, or have a fatal outcome by mid-adult life. This group comprises a small percentage of the total rheumatic fever cases. Not only are these progressive cases with a poor outlook small in relative numbers, but they usually become defined early in the course of the disease.

Since the incidence of serious heart disease following first attacks of rheumatic fever in adult life is smaller than that in children, it seems even more necessary to orient carefully the patient with regard to the problem, and prevent his overready acceptance of the fact that heart disease will become serious. It is hard to make this clear when policies vary with regard to the handling of those rheumatic fever subjects who either escape detectable heart disease or develop only slight degrees of cardiac damage. Apparently the susceptibilities of these two groups are similar. After suitable convalescence and reasonable rehabilitation, there seems little difference in the ultimate outcome of those individuals who have functionally good hearts, regardless of the pres-

ence or absence of slight cardiac enlargement and certain murmurs. Physical activity seems to have little effect on their ultimate prognosis, once the disease has become definitely inactive. Protection of these individuals against hemolytic streptococcal respiratory infections should be the most important part of any program designed for the promotion of their well-being. It is believed that the explanation of such features to rheumatic fever subjects by physicians will result in fewer psychological problems and a more active interest on the part of the individual in attempting to avoid exposure to hemolytic streptococcal infections.

It is rather surprising that, in a child of average intelligence, good cooperation may be obtained with regard to long bed rest, even in the presence of reasonable well-being, providing the child becomes aware of the fact that he is being restricted temporarily because of an active disease process and for the purpose of minimizing the amount of permanent heart damage sustained. In the past, we have encouraged children well over the active stage of the disease to return to active physical lives even in the presence of moderate degrees of heart disease. As yet, we have seen no harm result from this program. The patients getting into difficulty have done so, not as a result of physical activity, but because of hemolytic streptococcal infections.

PROBLEMS RELATIVE TO THE DISPOSITION OF RHEUMATIC FEVER PATIENTS IN THE ARMED SERVICES

The need for man power, especially the services of highly trained members of the Armed Forces, must of necessity dictate the ultimate disposition of those service men developing rheumatic fever. This problem is a difficult one with many aspects. As indicated before, a previous history of rheumatic fever results in an increased likelihood of an individual developing rheumatic fever, provided he is stationed in an area of high rheumatic fever incidence. So, too, will those individuals developing the disease in the Service for the first time show an increase in susceptibility to further attacks. The number of individuals developing incapacitating degrees of heart disease and progressive rheumatic fever will doubtless be small.

The presence or absence of heart disease following an attack of rheumatic fever may determine whether or not an individual is eligible for compensation and, therefore, may influence policies of disposition. Otherwise, the disposition of rheumatic fever cases should not depend upon whether such individuals develop slight degree of heart disease or fail to acquire any detectable cardiac damage. Both groups of individuals will be likely to develop repetitive rheumatic fever if they are exposed to hemolytic streptococcal respiratory epidemics, and hence it seems reasonable to handle them both in the same manner.

When programs of protection against hemolytic streptococcal infection are developed, the majority of these men can be of continued value to the Service without jeopardizing their health. Such programs need exploration and careful study. They will require trained personnel, but there can be little doubt of their importance and ultimate service in man-power saving and disease prevention.

What will eventually happen to men who have developed rheumatic fever for the first time while in the Armed Services is of importance. However, we do not at present know the actual natural history of rheumatic fever beginning in adult life. By adequate follow-up of the veterans of World War II we may learn whether there is any difference in the fundamental process when rheumatic fever appears for the first time at various ages, or whether variations in outcome are entirely dependent upon exposure to streptococcal respiratory infections and development of natural immunity to the hemolytic streptococcus. Many such features need clarification.

SUMMARY

Although the etiology of rheumatic fever is unknown, our knowledge is sufficient to warrant the development of programs of care. The close relationship between epidemic hemolytic streptococcal infections and rheumatic fever is discussed, and it is pointed out that rheumatic fever in a given population follows closely the epidemiology of hemolytic streptococcal infections. This pattern is so convincing that it forms the basis of prevention programs. Prevention programs are discussed, with especial emphasis on the careful study of respiratory infections from a bacteriologic point of view. Culturing, grouping, and typing of such infections offers a key to the streptococcus problem in a given epidemiological unit. The use of sulfonamides prophylactically is discussed. Other preventive measures than chemotherapy are mentioned.

The general problem of susceptibility, as well as considerations relative to the disposition of rheumatic fever patients in the Armed Services, are evaluated. Caution against developing an unfavorable psychology in rheumatic fever patients is emphasized. Numerous gaps in our knowledge are enumerated throughout the report.

A plea is made to accept the problem as perhaps the most serious feature of the general hemolytic streptococcal problem, and some measures are discussed which may be helpful in the prevention of rheumatic fever. The authors are cognizant of the fact that, despite the close relationship with hemolytic streptococci, as indicated, there are many unsolved problems relative to the disease. These problems are by no means limited to the hemolytic streptococci association, but represent a wide variety of biologic aspects.

FOREIGN BODIES IN AND ABOUT THE HEART

MAJOR EDWARD F. BLAND, M.C.

DURING the first six months of operation of the Sixth General Hospital, U.S. Army, in the North African theater eight patients have been encountered with penetrating chest wounds and retained metallic foreign bodies either in, or in close apposition to, the heart. Similar cases will probably be observed with increasing frequency as the war progresses, and the question will arise as to whether or not surgical removal should be attempted.

Recorded data helpful in this connection are scant since this type of injury is largely limited to combat operations and, hence, its counterpart in civilian practice is rare. Therefore, we are recording in this preliminary report the clinical features and x-ray findings in four of this series because of their special interest.

In these case reports the clinical notes and x-ray findings of the various medical installations in the chain of evacuation have been incorporated with our own studies. We regret that exigencies of the military situation make it impossible to render at this time full credit by name to the various individuals and installations involved.

CASE REPORTS

CASE 1.—*Bullet in the Right Side of the Heart.*—A staff sergeant, aged 25 years, in the field artillery, was in a battery holding an exposed position near Tebourba, in Tunisia, when it was attacked by 35 enemy tanks, on Dec. 6, 1942. During the engagement he was wounded by machine-gun bullets. Shortly thereafter, in a nearby dressing station, he was found to have two wounds of entrance in the left pectoral region and a superficial wound of the left wrist. Sulfanilamide dressings were applied and he was evacuated to a British general hospital.

On arrival his condition was satisfactory. There were no abnormal physical signs, but x-ray examination revealed a metallic foreign body in the heart and another fragment in the soft tissue of the left chest wall. The latter fragment was removed two weeks after his injury and, thereafter, he appeared to be making a good recovery without symptoms or signs referable to the intracardiac bullet.

Six weeks after his injury he began to have aching substernal discomfort, aggravated sharply by deep inspiration, with accompanying radiation through to the back, to both shoulders, and occasionally to both arms as far as the wrists. He appeared pale and breathless, and the area of cardiac dullness was enlarged to the left. The lungs were clear except for the signs of compression at the left lung base posteriorly. Fluoroscopic examination showed the heart shadow much enlarged and the cardiac pulsations reduced in amplitude. The bullet appeared to be within the right border of the heart. His temperature rose to 101° F., and he was started on chemotherapy.

At the end of a week he was much improved, and on fluoroscopic examination the cardiac shadow had decreased in size. At the end of three weeks the heart was normal in size and pulsations. The position of the bullet remained unchanged.

Nine weeks after his injury he again became ill with right-sided pleural pain followed by a moderate effusion. Aspiration yielded 150 c.c. of opaque, sterile fluid. In the course of the next two weeks he recovered from this second complication. In March, 1943, he was seen in consultation by Col. E. D. Churchill who advised against surgical exploration for the retained bullet.

Four months after receiving his wound, and in the course of evacuation to the zone of the interior, he first came under our observation. By this time he appeared to have made a complete recovery. The chest wound was well healed and physical examination revealed no abnormalities in the heart or lungs. Fluoroscopic examination at this time confirmed the presence of a sharp-nosed bullet (caliber .30), measuring approximately 2.3 cm. in length, lying within the shadow of the right side of the heart (Figs. 1*A* and 1*B*). It moved vigorously with each heartbeat. Lateral and oblique views showed the bullet in the midlateral portion of the heart, placed slightly anteriorly and most likely at or near the junction of the right auricle and ventricle. By rotation of the patient it was impossible to separate the shadow of the foreign body from that of the heart to an extent greater than is shown in Fig. 1*A*. Fully two-thirds of the bullet appeared to be embedded in the wall of the heart, possibly in a much thickened pericardium. Incidentally, in the course of our x-ray studies an additional, and previously unsuspected, fragment of metal measuring 1 by 0.4 cm. was discovered buried in the central portion of the liver. An electrocardiogram, including Lead IV, was normal except for a slight degree of right axis deviation, which was considered by us within the normal range for a vertically placed heart.

In May, 1943, five months after his injury, he was returned to the United States. His only complaint was occasional substernal discomfort, a sense of pressure, radiating to the upper right arm. It usually lasted one to two hours and was uninfluenced by motion, position, or respiration.

Comment.—It is extraordinary that a missile of this size could have traversed the chest without causing serious injury to the vital mediastinal structures. Undoubtedly its force must have been largely spent before it entered from a lateral direction and presumably followed the anterior contour of the thoracic cage, to be deflected inward along the structural plane between the right lung and heart. The delayed appearance of pericardial and pleural effusions, six and nine weeks, respectively, after the injury, is of some further interest.

CASE 2. *Foreign Body in the Left Side of the Heart.*—Sergeant, aged 22 years, in a tank destroyer battalion, was wounded in action while advancing on foot near Fonduk in Tunisia, April 13, 1943. A comrade who was 6 feet ahead of him stepped upon an antipersonnel mine and he (the patient) was jarred backward by the resulting explosion. He experienced immediate dyspnea but no pain, and attributed his breathlessness to the concussion. Not realizing that he had been wounded, he continued forward a few paces until he almost fainted and discovered blood upon his shirt. At the battalion aid station he was found to have a penetrating wound between the fourth and fifth ribs in the left anterior

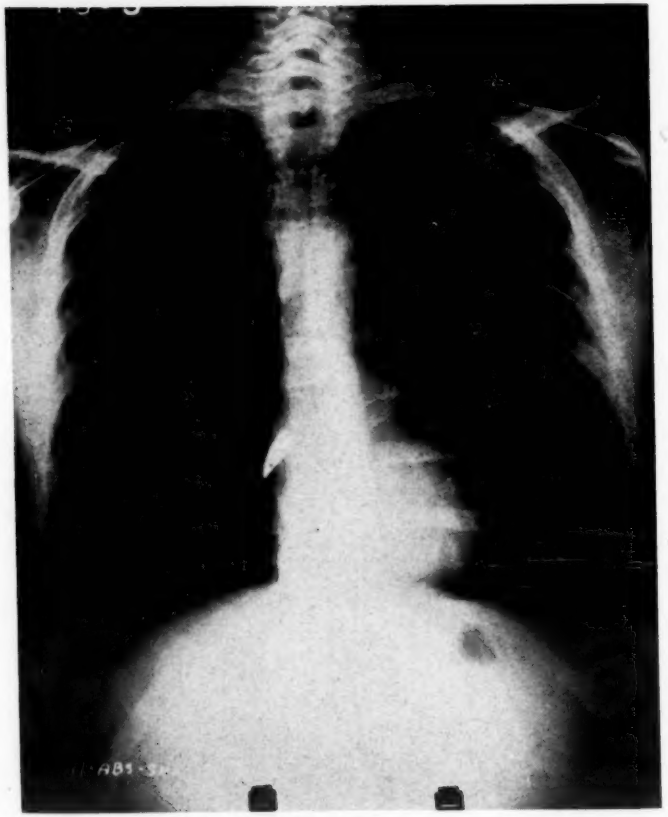

Fig. 1A.

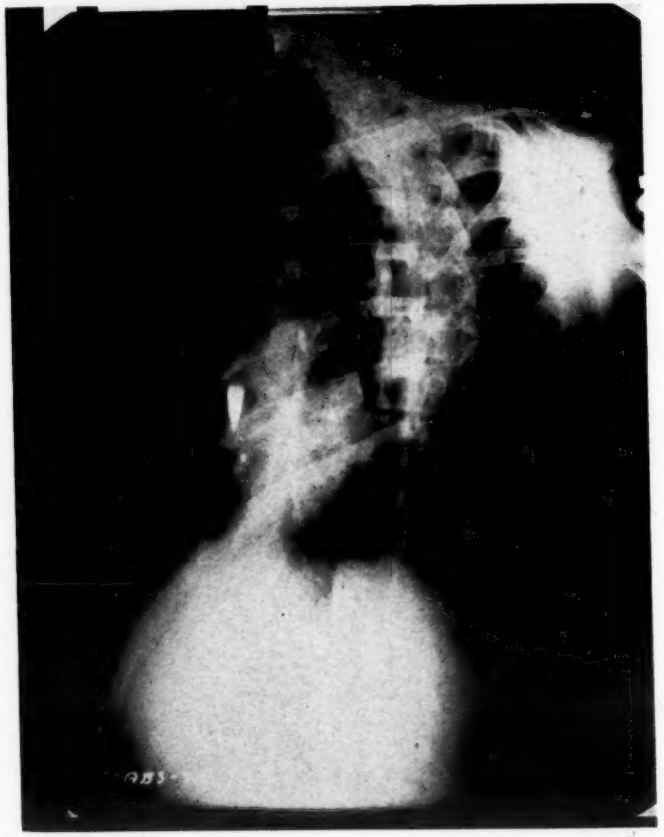

Fig. 1B.

Fig. 1*A*.—Case 1. Anterior-posterior view showing the bullet in the right wall of the heart.
Fig. 1*B*.—Case 1. A left anterior oblique view of the bullet in the right wall of the heart.

axillary line. Dyspnea continued and he raised small amounts of bloody sputum.

The following day, at an evacuation hospital, x-rays revealed a foreign body in, or near, the apex of the heart, and an exploratory thoracotomy was performed. A small sucking wound was found, and 8 cm. of the anterior portion of the fourth rib were removed. The pleural cavity yielded 500 c.c. of fluid blood. A slow hemorrhage from the anterior surface of the lower lobe of the lung was controlled by suture. At this point the patient went into rapid shock and further search for the foreign body was abandoned. A tight closure of the pleura and chest wall was obtained, and shortly thereafter the patient's condition began to improve. Chemotherapy had been administered from the onset, and by the end of the sixth day his condition was such that evacuation to the rear was accomplished in easy stages without untoward reactions.

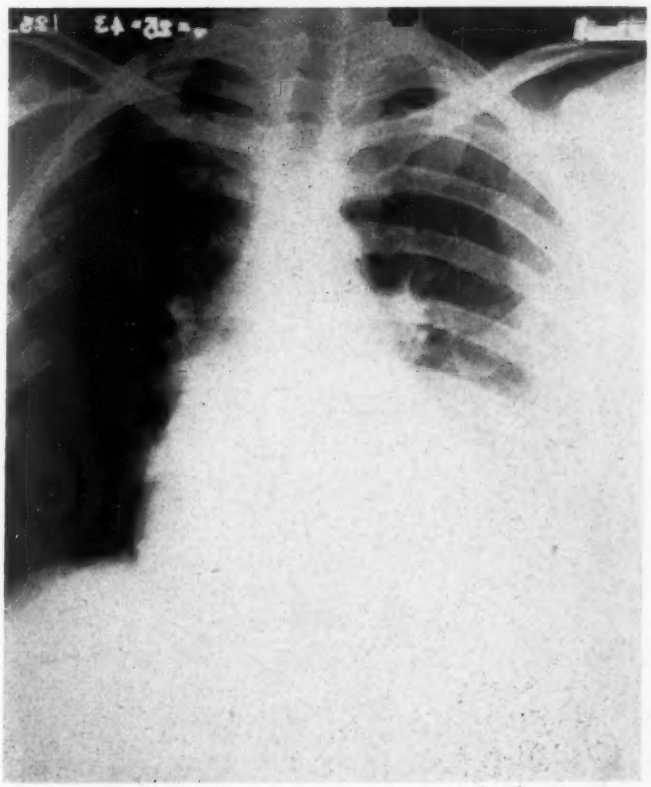

Fig. 2A.—Case 2. Roentgenogram taken at the time of the pericardial effusion. The bullet, visible at this time under the fluoroscope, well within the shadow of the heart, is not evident in this film.

Two weeks after the injury, while convalescing satisfactorily, he developed slowly increasing dyspnea at rest and a fever up to 102° F. Signs of fluid at the left base increased and pleural and pericardial friction rubs appeared. X-ray examination showed marked enlargement of the cardiac shadow as well as considerable pleural effusion (Fig. 2*A*). Fluoroscopically, the pulsations of the cardiac borders were feeble.

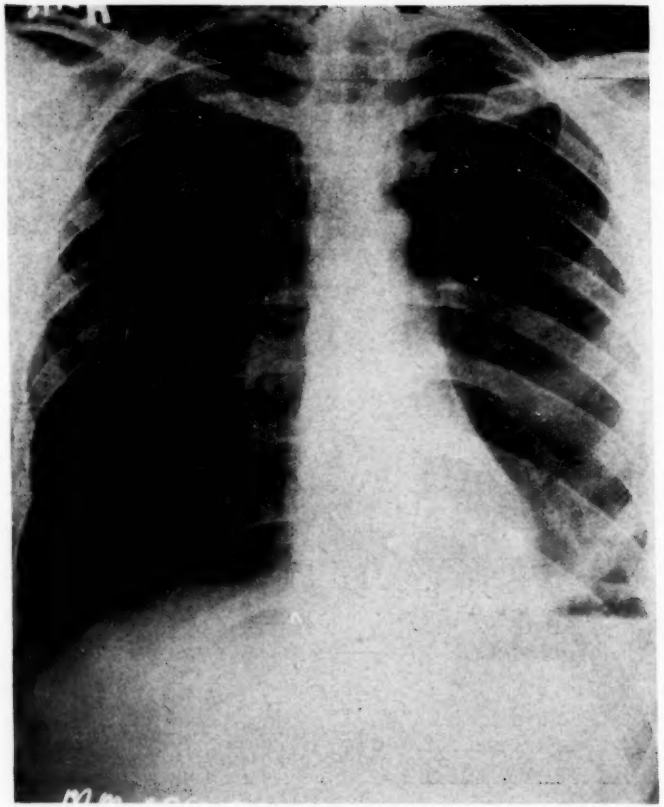

Fig. 2B.

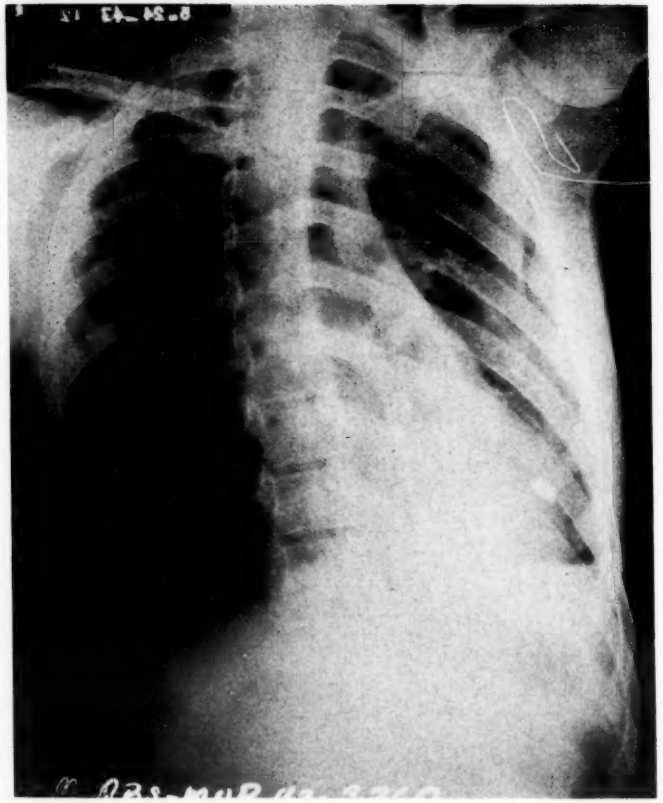

Fig. 2C.

Fig. 2B.—Case 2. Roentgenogram taken after subsidence of the pericardial effusion, showing the bullet in the wall of the left ventricle.

Fig. 2C.—Case 2. Right anterior oblique view showing the bullet in the heart wall.

The metallic foreign body, not discernible in the above reproduction of the film, was visible approximately 2 cm. inside the left border of the cardiac shadow and was seen to move slightly with each systole of the heart. Chemotherapy was resumed, and 650 c.c. of sterile serosanguineous fluid were aspirated from the pleural space. He progressively improved and subsequent x-rays showed a gradual diminution of both the pericardial and the pleural effusions.

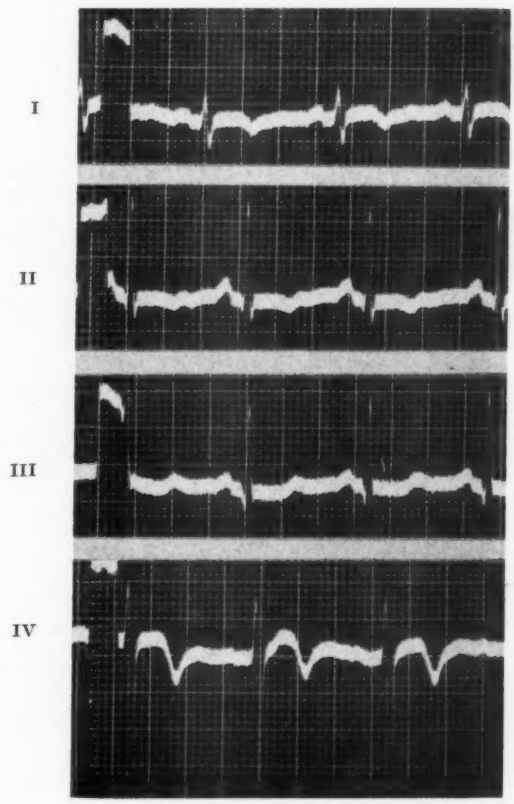

Fig. 3.—Case 2. The electrocardiogram showing inversion of the T waves in Leads I, II, and IV, consistent with myocardial injury in the region of the cardiac apex.

Six weeks after his injury he came for the first time under our observation. By this time his general condition was good, and his only complaints were: (1) dyspnea on effort, (2) a moderately bothersome and slightly productive cough, and (3) a feeling of muscle tightness on deep inspiration at the site of the wound, now well healed. X-ray and fluoroscopy at this time showed that the heart was now normal in shape, size, and pulsations. The foreign body lay within the cardiac shadow in its entirety and was located anteriorly just above the apex of the heart, presumably in the wall of the left ventricle (Figs. 2*B* and 2*C*). It moved inward vigorously with cardiac systole and there was no evidence of aneurysmal bulging of the heart wall in this vicinity. A hydropneumothorax of moderate degree persisted.

An electrocardiogram was characteristic of myocardial injury in the region of the cardiac apex (Fig. 3). It showed a sharp late inversion of the T waves in Leads I, II, and IV, with a slight elevation of the S-T segments in Leads I and IV.

Comment.—Two months after his injury this patient was evacuated to the United States. It appears as though he will make a complete recovery, barring pulmonary complications. The retained foreign body is probably firmly embedded in fibrous tissue without seriously weakening the heart wall. Therefore, the danger of disastrous erosion later seems negligible, especially since the force of each heartbeat is directed away from, rather than against, the retained metal. Here again, as in Case 1, the somewhat delayed appearance of pericardial effusion without serious consequences is of interest.

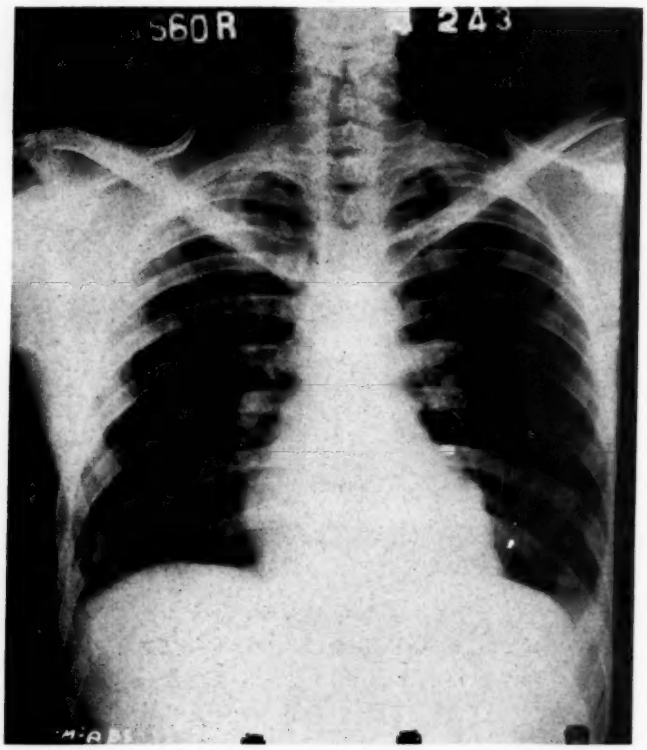

Fig. 4*A*.—Case 3. Roentgenogram showing a pneumopericardium and a retained foreign body which, in oblique views, lies behind the heart.

CASE 3. *Pneumopericardium With a Foreign Body in the Adjacent Lung.*—A sergeant in the infantry, aged 24 years, was wounded on March 30, 1943, by mortar shell fragments near El Guettar in Tunisia. He received a flesh wound of the left forearm and a perforating wound of the left chest wall in the lower part of the axilla. He immediately experienced severe dyspnea and sharp pain in the left chest on inspiration, radiating upward into the left side of the neck. For about an hour there was a sucking sensation at the site of the chest wound, and he coughed up blood for twenty-four hours. His dyspnea slowly subsided

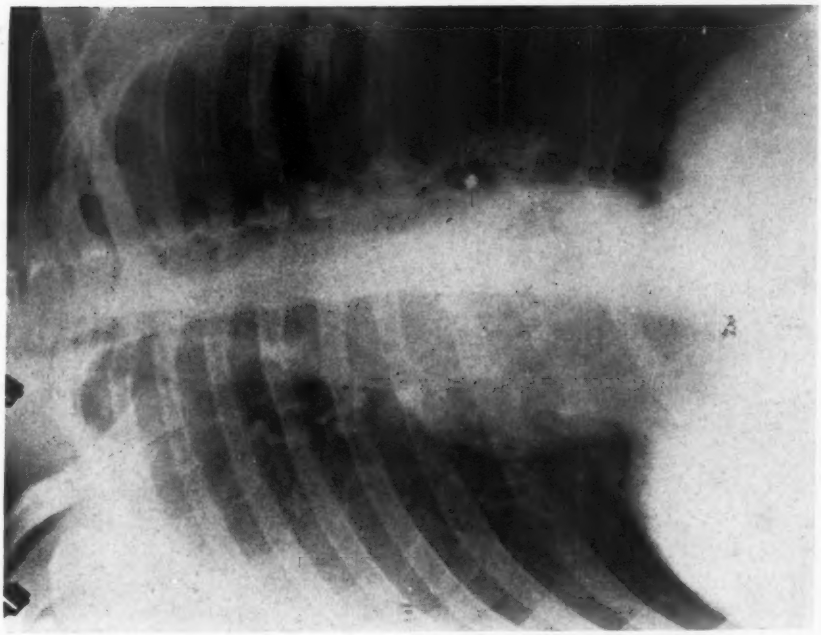

Fig. 4C.

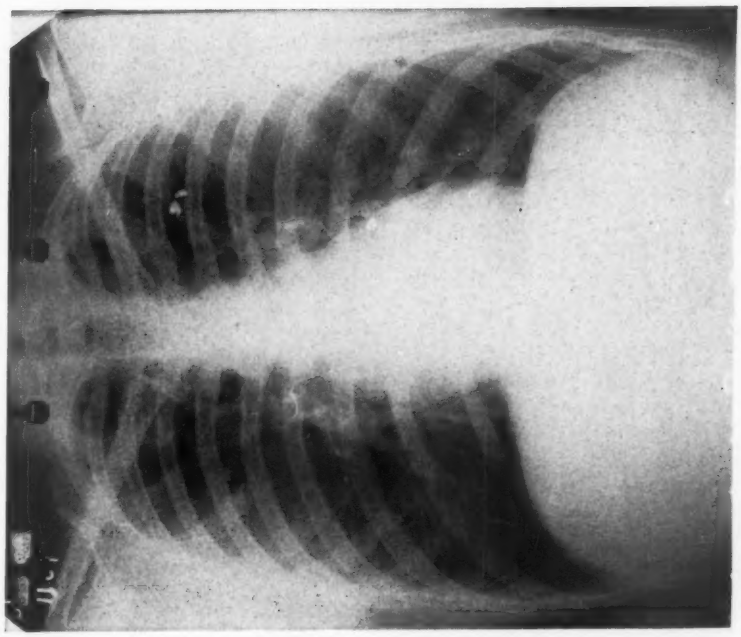

Fig. 4B.

Fig. 4B.—Case 3. Roentgenogram after the pneumopericardium had subsided.
Fig. 4C.—Case 3. A left anterior oblique view showing the foreign body close behind the heart.

in the course of two to three days. No friction rubs were heard and his general condition was good throughout this time. On the third day he was evacuated to a general hospital where the x-ray shown in Fig. 4*A* was taken. It shows a small metallic foreign body near the heart and a pneumopericardium. The outline of the pericardium is shown by the thin line of density beyond the left border of the heart.

He came under our observation on the tenth day after his injury. He still complained of an occasional sharp stabbing pain along the left border of the heart on deep inspiration, but no friction rub could be elicited. He appeared to be in good condition. The wound of entrance in the left axilla was healing satisfactorily. Examination of his heart and lungs revealed no abnormalities. An electrocardiogram was slightly abnormal in that the T waves were of low voltage in all leads, the greatest amplitude being 1 mm. in Lead I, whereas the voltage of the QRS complexes and the P waves was normal and of good amplitude in all leads.

X-ray examination and fluoroscopy by us at this time showed a 7 mm. rounded foreign body lying about 1 cm. behind the heart near the left auricle (Figs. 4*B* and 4*C*). It exhibited no motion with the heartbeat, but there was slight movement with respiration. All evidence of the pneumopericardium had subsided and the left border of the heart now followed the contour previously outlined by the pericardium (compare Fig. 4*A* and Fig. 4*B*).

Comment.—Although he had apparently recovered, he re-entered the hospital three months after his injury, after a trial of light duty, because of intermittent discomfort in the region of the wound of entrance, brought on by effort and aggravated by deep breathing. Because of this, and also because of the greater risk of pulmonary infection from continued sojourn in this theater, he was evacuated to the United States.

Case 4. *Multiple Fragments of Unusual Origin in the Heart and Lungs.*—A private first class, aged 27 years, came under our observation in July, 1943, with the following history.

In 1936 while hunting rabbits, he was accidentally shot by a friend by a caliber .22 rifle from a distance of about 50 feet. The bullet entered the third intercostal space just to the left of the sternum, penetrated the chest, lodged against and fractured the eighth rib posteriorly on the right side. He was knocked unconscious by the blow, and upon recovery found that he had been taken to a nearby hospital. For several days he raised bloody sputum and had severe pain in the right side of the chest. During the third week the bullet was removed from the chest wall (he has it at home as a souvenir). Thereafter he made a good recovery, but he has a led a quiet life since then because unusual effort causes vague discomfort in the right side of the chest.

In 1938 he spent three weeks in a hospital because of right-sided pleurisy, which was relieved by strapping, but paracentesis was not necessary. Since then he has been bothered by a "catching" pain at the angle of the right scapula on deep inspiration, or upon certain abrupt movements of the trunk. During the Tunisian campaign he had difficulty in keeping up with his company because of an aggravation of the above discomfort and, hence, he was sent to the hospital for study, in July, 1943.

On physical examination he appeared to be in excellent condition and the only positive findings were: (1) a circular scar 1 cm. in diameter in the third interspace just to the left of the body of the sternum, (2)

a small operative scar at the lower angle of the right scapula 1.5 cm. in diameter where the bullet had been removed, and (3) slight irregularity and deep tenderness over the eighth rib in this region. An electrocardiogram was normal.

Fluoroscopy and x-ray films revealed the extraordinary picture of multiple small metallic foreign bodies scattered throughout the right side of the thorax (thirteen were identified) (see Figs. 5*A*, 5*B*, and 5*C*).

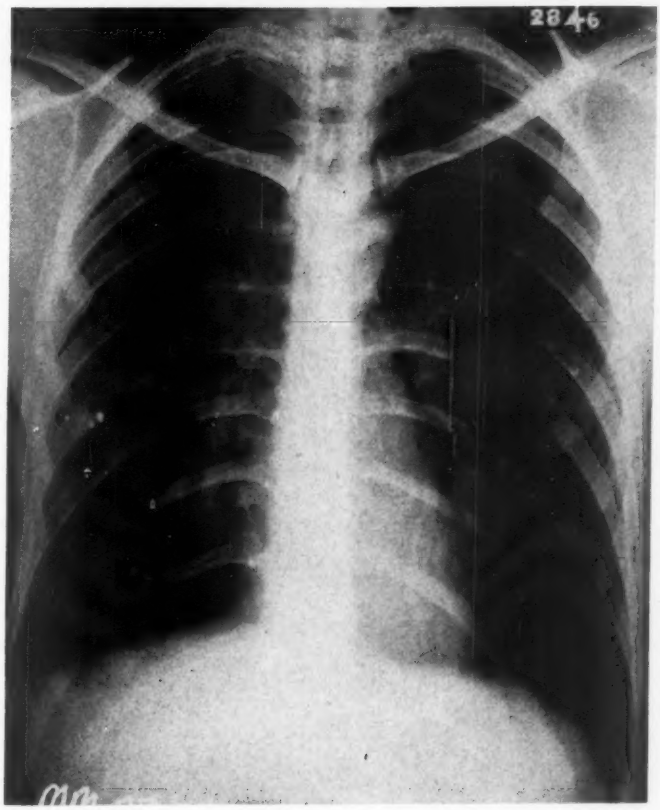

Fig. 5*A*.—Case 4. Roentgenogram showing multiple small foreign body fragments in the right lung and heart wall.

At the site of the now well-healed fracture of the eighth rib in the right posterior axillary line, we localized three fragments measuring up to 4 mm. There was moderate bony overgrowth of the rib in this region and thickening of the adjacent pleura. Also, in the right mid-lung field there was a collection of tiny metal fragments with localized fibrosis of the lung in this region. Likewise, at the hilus of the right lung, close to the heart and moving slightly with respirations, we counted four U-shaped fragments measuring up to 4 mm. in their greatest diameter. And finally, in the right anterior oblique view, well shown in Fig. 5*C*, could be seen three additional foreign bodies within the heart shadow in the region of the right auricle. They moved vigorously with each cardiac pulsation. The activity of the lowest of the three was most marked with a range of motion estimated at 1 cm.

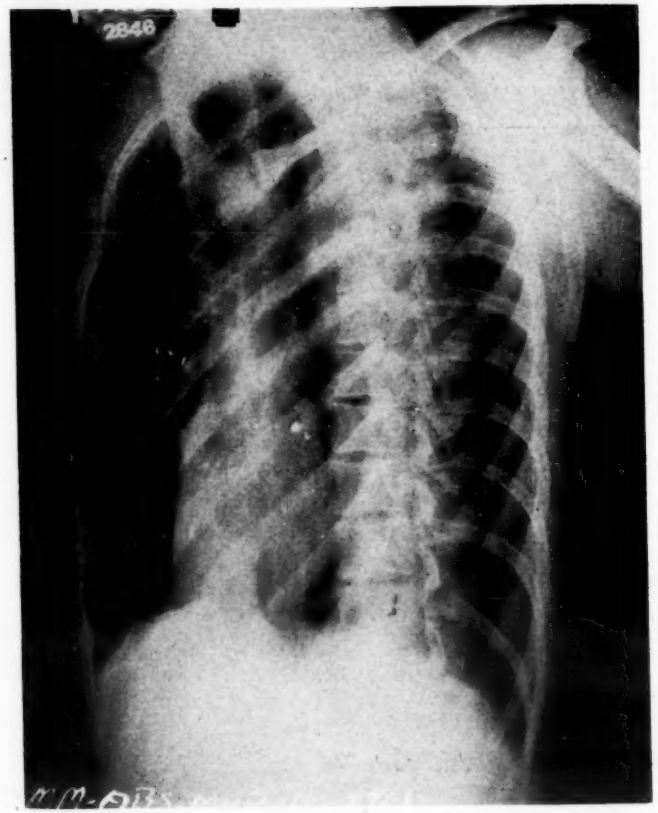

Fig. 5*B*.

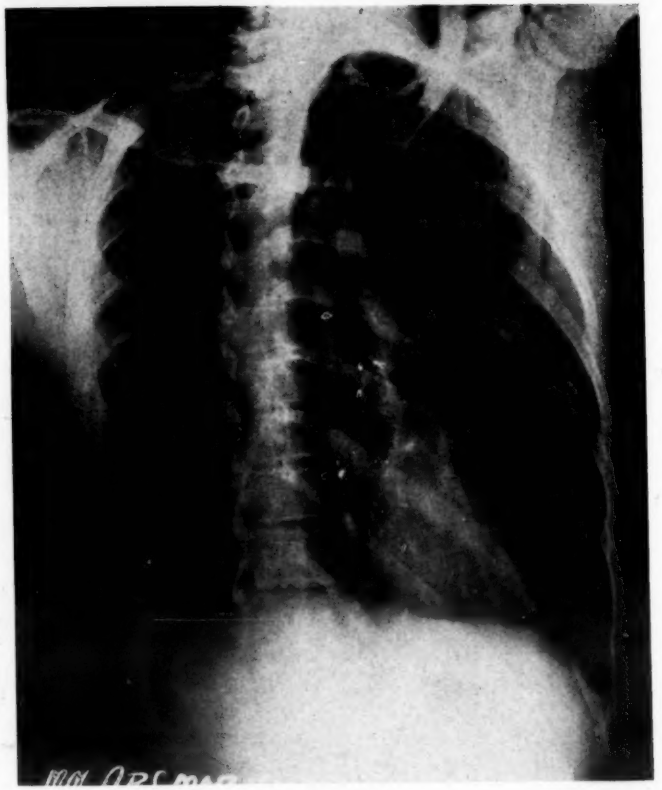

Fig. 5*C*.

Fig. 5*B*.—Case 4. A left anterior oblique view showing the peculiar U-shaped contour of some of the fragments.

Fig. 5*C*.—Case 4. A right anterior oblique view showing three small fragments in the posterior wall of the heart. The U-shaped contour of several is also well seen in this view.

Comment.—At first glance we were puzzled as to the source and nature of these numerous small fragments so widely scattered through the right lung and heart wall, especially since the entire bullet had been removed shortly after his injury seven years before. However, the multiplicity, the uniformly small size, and the peculiar U-shaped appearance of some of these fragments gave us a clue. On requestioning, the patient recalled that on the day of his accident he was wearing a heavy hunting shirt fastened by a 6 inch zipper in front, the position of which corresponded with the point of entrance of the bullet. Unfortunately, the patient never saw his shirt after the accident and nothing was ever said to him as to its damage other than that it was "ruined." It seems, however, that a zipper shattered by the impact of the bullet offers the most likely explanation as to the source of these fragments of metal. His present symptoms are probably due to persistent irritation at the site of the healed fracture. Removal of the retained fragments underlying this rib is probably indicated but, because of other considerations, the patient has been returned to the United States for further study and treatment. There is no indication that the fragments retained in the heart wall or in the substance of the lung have caused serious trouble.

CONCLUDING REMARKS

The favorable course of these four patients, in spite of the temporary complication of pericarditis with effusion in two instances, together with a similar favorable outcome in the remaining four patients in this series, illustrates again the now well-known ability of the heart to withstand physical injury and even to tolerate sizable slugs of metal within, and adjacent to, its walls.

It is our plan to follow the subsequent course of these patients to determine if later ill effects result from the retained metallic bodies. The available data suggest a relatively uncomplicated future, as illustrated by Case 4, and also by an additional patient in this series (Case 5), not reported in detail here, who was shot accidentally in 1925 by a caliber .38 revolver. The retained bullet lies directly against the ascending aorta, moving vigorously with each pulsation. During the ensuing eighteen years this patient has attained some renown as a prize fighter and has had no symptoms related to the intrathoracic bullet.

In the remaining three patients of the series there have been no serious complications, and the foreign bodies are located as follows:

CASE 6.—There are two fragments in the heart muscle, one of which lies anteriorly in the region of the aortic orifice and moves violently with each heart beat; the second lies posteriorly in the cardiac wall near the junction of the left auricle and ventricle. The electrocardiogram shows late inversion of the T waves in all four leads.

CASE 7.—There is a jagged metallic fragment measuring 2 by 0.5 cm. at the lower anterior border of the heart in the region of the right ventricle. The electrocardiogram is normal.

CASE 8.—In the right posterior aspect of the heart, probably in the wall of the right auricle, or in the pericardial tissue, there is a 7 mm. fragment of metal which moves so vigorously with each heartbeat that it is photographed with difficulty. The electrocardiogram is normal.

SUMMARY

The case histories of four patients (from a series of eight) with penetrating chest wounds and retained foreign bodies in, or adjacent to, the heart are recorded. Pericardial effusion was a complicating feature of two, pneumopericardium of one, and the fourth case was included because of the unusual origin of the retained metal fragments, namely, a shattered zipper. The available evidence suggests that the later course of these patients will be favorable.

I am indebted to Lt. Col. James R. Lingley and Capt. Stanley M. Wyman of the X-ray Department for their interest and expert aid in localizing the foreign bodies recorded in this report, and to the Signal Corps for the illustrations.

THE CARDIOVASCULAR SYSTEM IN TRAUMATIC SHOCK

SEYMOUR S. KETY, M.D.,* AND ALFRED POPE, M.D.

INVESTIGATIONS on secondary or traumatic shock were first undertaken on a large scale as a result of the importance which this problem assumed during World War I. A large body of clinical and experimental observations were recorded then and well summarized in the monograph by Cannon,[1] published in 1923. Moreover, during the interval between the war, 1914 to 1918, and the outbreak of the present conflict, a voluminous literature on shock has appeared. Study of this material permits the formation of a reasonably clear picture of the fundamental cardiovascular disturbance, the chain of events leading to death, and the relative importance of various possible initiating factors. The following discussion will be limited to a consideration of studies in this field which already have been published, and, for obvious reasons, no reference will be made to any of the very extensive and confidential investigative programs which are at present in progress on many aspects of the shock problem.

The best short definition of shock is that of Harkins,[2] "a progressive, vasoconstrictive, oligemic anoxia." Most of the essential elements of its pathologic physiology are implicit in this definition, and these can be most readily amplified and illustrated by resorting to a diagrammatic representation (Fig. 1), for many features of which we are indebted to Blalock,[3] McDowall,[4] Moon,[5] and Freeman.[6]

The bracketed phases of this diagram constitute the fundamental hemodynamic disturbances of traumatic shock and account fully for its specific clinical features. It is essential to differentiate between these primary circulatory factors and the nonspecific environmental and functional alterations in the tissues, which result from reduction in blood flow, and which lead to a fatal outcome when occurring in the vital organs. It is also important to emphasize that this potential cycle of shock may be initiated at any one or more of its several constituent stages, and that only factors which act in this way can be of etiological significance.

The following discussion will be concerned first with the relatively well-established specific circulatory changes that occur in shock, and

From the Medical Laboratories of the Collis P. Huntington Memorial Hospital of Harvard University, at the Massachusetts General Hospital.

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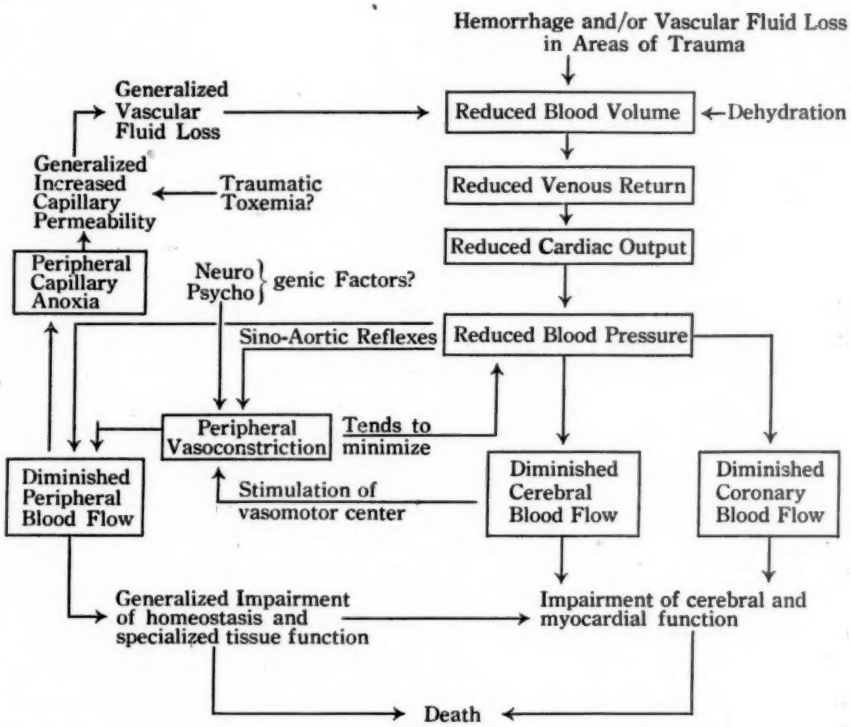
*Formerly Fellow in Medical Sciences, National Research Council. Present address: Department of Pharmacology, University of Pennsylvania Medical School, Philadelphia, Pa.

Fig. 1



their consequences to the economy of the organism. There will follow a brief consideration of more controversial matters, including the problem of etiological factors and that of the state of "irreversible" shock.

FUNDAMENTAL HEMODYNAMIC DISTURBANCE

Whatever may be their differences on other aspects of the problem, all who have studied traumatic shock in recent years are in substantial agreement upon the disturbances in cardiovascular function which characterize it. These may be expressed as a sequence of events resulting from reduction in blood volume and leading in turn to diminution in venous return, reduction in cardiac output, reduction in blood pressure, and consequent decrease in blood flow to vital centers. Each step in this sequence not only is reasonable on purely theoretical grounds, but also is substantiated by measurements in experimental animals, and many of the cardiovascular derangements are being corroborated by studies on traumatic shock in man. Noteworthy are the extensive clinical investigations carried on at the Bellevue Hospital in New York,[7] to which we shall have occasion frequently to refer.

All the evidence indicates that a reduction in effective blood volume is of fundamental importance. Recently, it has been emphasized that some of this reduction may represent blood which is trapped in occluded vascular beds;[8-10] but, nevertheless, such sequestered blood is

effectively lost to the circulation. In severe traumatic shock in man the average reduction in blood volume has been found to approximate 40 per cent.[7]

The early and marked reduction in right auricular pressure which is constantly found in all types of shock[7, 11-13] is reasonable evidence of a significant reduction in venous return, upon which undoubtedly depends the severe diminution in stroke volume[7] and cardiac output per minute.[7, 11, 14, 15] The contrast between this mechanism by which the cardiac output is reduced, and primary myocardial failure is obvious.

The reduction in cardiac output is the precursor of the fall in blood pressure which has classically characterized the shock syndrome, although as a result of certain compensatory changes the earlier disturbances may progress considerably before a significant hypotension occurs. Since the maximal flow of blood through the cerebral and coronary vessels is limited by the intra-arterial pressure, this fall in blood pressure assumes grave significance.

By invoking certain compensatory mechanisms, however, the organism is enabled to survive a reduction in effective blood volume which would otherwise lead rapidly to death. There is evidence that moderate blood loss is not followed by a significant decrease in cardiac output,[16] which may indicate a certain blood volume reserve brought into play by venous constriction. A fall in blood pressure, through diminution of the inhibitory impulses from pressure receptors in the carotid sinus and aortic arch,[17] causes an increase in cardiac rate and, augmented possibly by direct stimulation of the vasomotor center through severe decreases in cerebral blood flow,[18] produces a generalized peripheral arteriolar constriction. In this, the cerebral and coronary vessels take little part because of their relatively ineffectual constrictor innervations,[19-21] and the net effect is a redistribution of the diminishing output of the heart toward the brain and myocardium at the cost of a great reduction in blood flow through less essential vascular beds such as those of the skin, gastrointestinal tract, kidneys, and muscle.[22] Although an increase in the total peripheral resistance[59] and diminished circulation in certain regions have been demonstrated experimentally,[23-25] the only measurements in clinical shock (complicated unfortunately by alcoholism) show reduction in total peripheral resistance.[7]

The rate and depth of respiration are increased as a result of both direct and reflex stimulation of the respiratory center,[17, 18, 20] and these respiratory changes persist throughout all but the terminal stages of shock. They occur before there is a significant change in arterial carbon dioxide tension or pH, and one of the results may be to augment venous return through exaggerated fluctuations in intrathoracic pressure.

The combination of diminished arterial pressure and generalized arteriolar constriction results in a considerable fall in the effective capillary filtration pressure. Mobilization of extravascular fluid is thus achieved, and the first step in the restoration of plasma volume is

initiated. If the organism is able to survive the early effects of blood or plasma loss, regeneration of plasma protein and cellular elements occurs to complete the restitution.

There has been unwarranted emphasis on arterial or venous hematocrit values as an index of plasma loss or gain. A layer of relatively stagnant plasma adjacent to vessel walls, which is of appreciable magnitude in the smaller vessels, has been demonstrated.[26] This makes the erythrocyte concentration in capillary blood considerably lower, and, in great vessel blood, higher, than the average body hematocrit. Furthermore, since this plasma layer varies in magnitude according to the total capillary surface and velocity of blood flow, changes in these factors may cause misleading changes in the hematocrit values of blood taken from peripheral veins.[27] Such effects as these may explain the inconsistent results of hematocrit determinations in various types of shock. Although hemorrhagic shock has usually been thought to be associated with hemodilution and traumatic shock with hemoconcentration on the basis of hematocrit studies, one group has recently reported[7] consistently reduced red cell hematocrits in cases of shock from skeletal trauma without evidence of gross hemorrhage.

From these fundamental disturbances stem all the clinical manifestations which have long been recognized as characteristic of shock. The feeble pulse and low pulse pressure are reflections of the diminished stroke volume and increased peripheral resistance. The tachycardia and hyperpnea arise from reflex and central mechanisms already discussed, while the pallor, clammy skin, and cold extremities are manifestations of generalized sympathetic activity and diminished peripheral blood flow. Mental indifference, drowsiness, or stupor are undoubtedly signs of a severely depressed cerebral blood flow.

IMPAIRMENT OF HOMEOSTASIS AND MECHANISM OF DEATH

The foregoing discussion has shown that the most serious consequence of primary reduction of blood volume is a diminished blood flow to the brain and heart and to the peripheral tissues. It has also been emphasized that the relative ischemia of the latter is greater than that of the former because of the additive effects of peripheral vasoconstriction and reduction of blood pressure. Indeed, compensatory reactions may maintain the blood pressure at normal levels so that cerebral and coronary blood flow is unaffected, but only at the expense of a greatly diminished peripheral flow.

The normal circulation of blood is by far the most important factor in the maintenance of the homeostasis of the tissues. Homeostasis is the term used by Cannon[28] to denote his far-reaching concept that the complex functional activities of all specialized organs and tissues of multicellular animals are directed toward the maintenance of constancy in the chemical and physical environment of all cells, similar to that in the seas in which living processes had their origin. Diminution

of blood flow to a tissue will, therefore, be followed by a serious disruption of homeostasis. Not only is there a reduction of the delivery of oxygen, oxidizable substrates, and other nutrients, but there is impairment in the removal of carbon dioxide and nitrogenous and acid end products of tissue metabolism. Sufficient lowering of the oxygen tension will result in interference with oxidative reactions, and owing to the consequent block in terminal oxidations, fermentative breakdown of carbohydrates undoubtedly tends to become predominant. An important and harmful consequence of these changes is the production of acidosis[29, 30] due to the accumulation of lactic[31] and other fixed acids in the blood stream. All of these metabolic and environmental abnormalities eventually lead to interference with the specific functional activities of the tissues. Breakdown of the integrity of cell membranes releases intracellular constituents, which may appear in high concentration in the blood as in the case of creatine[32] and potassium.[33] Capillary anoxemia, if prolonged, may result in increased permeability and perpetuation of the shock cycle, as will be discussed in connection with the problem of irreversible shock.

Although the degree of ischemia is less marked than in the peripheral tissues, losses of functional integrity eventually occur in the heart[34] and in the central nervous system, and in these organs such changes lead directly to death, which is usually the result of respiratory failure.

INITIATING FACTORS

The most controversial aspect of the shock problem concerns the mode by which the characteristic progression of changes is initiated. Theoretically, reduction in blood volume can be brought about by any factor that sets in motion the potential vicious cycle. In clinical shock such factors could include primary vascular fluid loss, intense neuropsychogenic stimulation, and the action of hypothetical toxins derived from traumatized tissue. Experimentally, shock can be produced in any of these ways, but great caution is necessary in the interpretation of the results of such experiments, and much confusion has arisen from the conclusion that because a given factor could initiate this progression of events, it must, therefore, be of etiological significance in clinical shock.

It is self-evident that gross uncomplicated hemorrhage can induce these changes, and the important work of Blalock,[35-37] of Parsons and Phemister,[38] and of others has clearly shown that the local fluid loss in traumatized areas is entirely sufficient to account for the shock that develops under the conditions of their experiments. There is now rather general agreement that primary vascular fluid loss at the site of injury is by far the most important factor in the genesis of subsequent shock. In this connection it is of some interest to quote from an excellent clinical study of actual battle casualties in England during the present war, by Keckwick, Marriott, Maycock, and Whitby,[39] "In all cases of trau-

matic shock seen by us it has appeared that the loss of blood volume can be accounted for by external loss and by extravasation into the injured area. In no case has there been any evidence to suggest a loss of plasma in regions remote from a seat of injury."

The theory of traumatic toxemia postulates the elaboration of a toxic factor in damaged tissues which is absorbed into the circulation and has a generalized action in bringing about a reduction in blood volume and hemoconcentration, either by causing peripheral stagnation and pooling of the blood in dilated venous or atonic capillary beds, or by producing a primary generalized increase in capillary permeability.

The toxic theory of shock is based upon two types of experimental evidence. In one, shock is produced in animals by the parenteral administration of various extracts of normal and traumatized tissues.[4, 40] In the other, attempts are made, either by cross-circulation or cross-transfusion experiments of varying degrees of complexity,[41-43] or by measurement or control of local fluid loss,[44-48] to show that some factor other than fluid loss is necessary to explain the production of shock in animals subjected to various forms of trauma. Experiments of the first type are not always consistently positive, especially when the element of bacterial contamination is controlled,[49] and at best they furnish only indirect evidence for the activity of toxic substances derived from traumatized tissues. Careful scrutiny of experiments of the second type reveals that in every case either other factors have not been adequately controlled, or traumatic fluid loss is sufficient to explain the results.*

The neurogenic theory of the etiology of shock depends upon the assumption that either there is sequestration of blood in postarteriolar vascular beds, or that prolonged severe vasoconstriction will result eventually in capillary leakage and hence reduction in blood volume. That the latter can occur experimentally has been shown by the work of Freeman,[50] and clinical experience has indicated that nervous and psychic factors may hasten or accentuate the development of shock in wounded individuals. There is, moreover, considerable experimental evidence[6, 10, 24, 51, 52] which appears to support this theory. However, in most laboratory experiments neurogenic factors are controlled by the use of barbiturate anesthesia, and both the neurogenic and toxic theories are rendered open to serious question by the inability of investigators to find evidence for an increase in capillary permeability in either clinical[7, 39] or experimental shock.[53] Moreover, many experiments have shown that when fluid loss in traumatized regions is prevented, shock fails to develop.[54-56]

It seems reasonable, therefore, to state that hemorrhage and traumatic effusion each has been demonstrated to be a necessary and sufficient cause for the development of shock, and that while other factors (neurogenic, toxic) have not been shown to be necessary causes, they

*A critical analysis of experimental studies bearing on the toxic theory of shock will be included in a future publication.

are sufficient ones under certain experimental conditions and have not been excluded as playing at least a contributory role in the genesis of both experimental and clinical shock.

THE PROBLEM OF IRREVERSIBLE SHOCK

It is possible with care and, when necessary, by removal or transfusion of appropriate amounts of blood, to maintain an animal in a state of severe hypotension with arterial blood pressures of about 30 to 40 mm. for a period of several hours. If the circulatory embarrassment has been sufficiently severe and prolonged, a state is reached in which even the reinjection of all blood removed will result in no improvement, and death cannot be prevented. Post-mortem examination of such animals usually reveals hemorrhage into the gastrointestinal tract and visceral congestion.[34, 57] Until recently, a satisfactory explanation for this irreversible state lay in the supposition that intense peripheral vasoconstriction, by virtue of the capillary blood stagnation and anoxemia, so damaged the endothelium as to render it permeable to blood colloids and cellular elements. That such a chain of events is possible is indicated by the experiments of Freeman and collaborators[50] who were able to produce fatal shock with demonstrable gastrointestinal hemorrhage by the continuous intravenous administration of epinephrine. Landis[58] has shown that capillary stagnation and anoxia may result in abnormal endothelial permeability. Fine and Seligman[9] found evidence of loss of tagged plasma protein into some organs in the last stages of hemorrhagic shock. The bulk of evidence indicates, however, that generalized loss of plasma proteins either does not occur,[7, 8, 39] or if it occurs, is insufficient to explain the state of irreversibility.[9, 34] Two other mechanisms have been offered as possible explanations for this puzzling phase of shock: a pooling of blood in the postarteriolar vascular bed,[8] and myocardial failure.[34, 59] Further studies are necessary before their relative roles can be evaluated.

Irreversibility is apparently an important cause of therapeutic failures in cases of human shock,[60] and elucidation of its pathologic physiology is, therefore, imperative.

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References to the literature on traumatic shock are necessarily limited to certain articles especially pertinent to the present discussion. Extensive and complete bibliographies on shock are available in the excellent reviews of Harkins[2] and Wiggers.[34]

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